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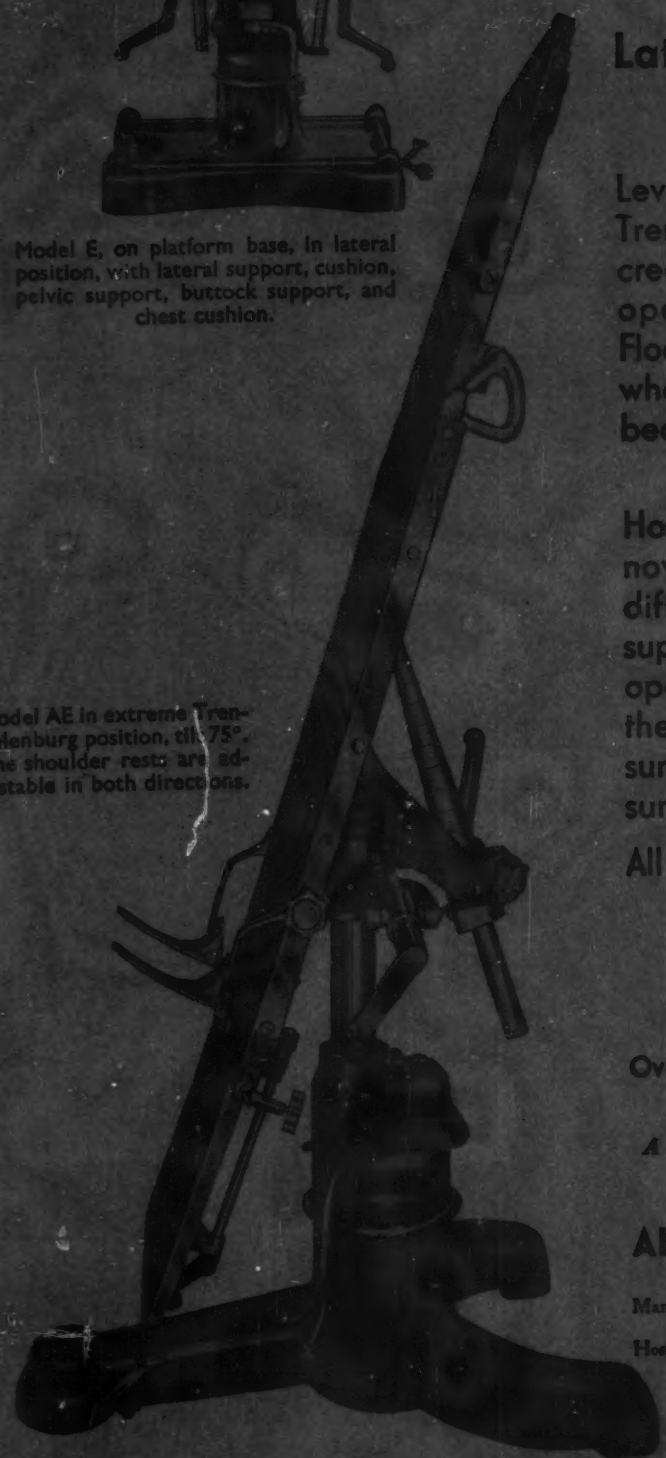

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THE
BRITISH JOURNAL OF SURGERY

VOL. XXIX JULY, 1941 No. 113

In Memoriam

SIR D'ARCY POWER, K.B.E.
(1855–1941)

THE BRITISH JOURNAL OF SURGERY has every reason to mourn the passing of Sir D'Arcy Power, for he was part and parcel of its being. In the capacity of Assistant Treasurer and Treasurer he had occupied a place on the Editorial Committee from the very outset. He was very rarely absent from the meetings and only resigned a month or two before his death.

Under his guidance the finances of the JOURNAL prospered. He was good at negotiations and could drive a bargain, and in these tragic days we have reason to be grateful for his constant insistence on the necessity of providing for a rainy day.

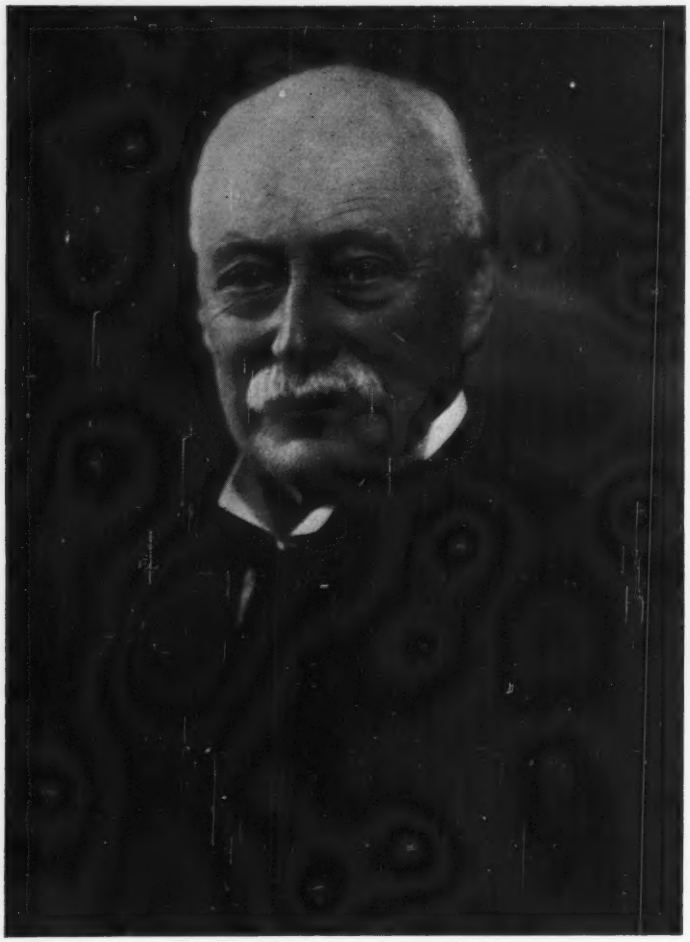
But in the affairs of the JOURNAL he was much more than its Treasurer; he was an " influence " and a " presence " which did much to help to sustain the high standard of our endeavour.

He was also a natural bridge between the book world and ourselves. We must recall with satisfaction and gratitude how he shouldered the task of producing the two Decennial Indexes, which are such useful guides, not only to our contents but to the progress of British surgery. His services as a contributor were also distinguished and memorable. Between the years 1913 and 1936, that is from vol. I to vol. XXIII, there appeared no less than 60 communications from his pen. In the early days there were four clinical communications, notable in their variety and interest, but it was the historical contributions which followed that stamped his connexion with the JOURNAL for most readers. These first appeared under the title " Eponyms ", then " Epoch-making Books in British Surgery ", followed by " Some Bygone Operations in Surgery ", and finally the series " Ipsissima Verba ". Doubtless many readers were first stimulated to an interest in surgical history by their perusal.

In recognition of his services to the JOURNAL and to commemorate his seventy-fifth birthday, the number for October, 1930 (vol. XVIII, no. 70), was dedicated to Sir D'Arcy and contained an excellent contemporary portrait. Fortunately this milestone was succeeded by another decade of stimulating activity.

The details of his professional life form a prodigious catalogue, by no means complete in any of the obituary notices which have thus far appeared. Here it is enough to record that Sir D'Arcy was born in 1855 and that his life was wrapped up with the traditions and work of St. Bartholomew's Hospital, which he loved

so well and which he served in one capacity and another for the long period of fifty-nine years. But his interests were manifold and interchangeable, for his hobbies were historical, antiquarian, and bibliographical, and his London provided an ample field for their exercise. But above all he loved his fellows and radiated cheerful helpfulness and encouragement all round. There was nothing exclusive



SIR D'ARCY POWER, K.B.E.
1855—1941

about this man of great heart, and the merest tyro was willingly helped and very often without the request that always brought a ready response.

It has been given to few members of our profession to be so much appreciated throughout the whole of a long life, and, despite his eighty-six years, his death carried this great gentleman off not far beyond the full tide of his usefulness.

THE POST-OPERATIVE COMPLICATIONS OF PULMONARY LOBECTOMY*

A CLINICAL AND EXPERIMENTAL STUDY

By F. J. SAMBROOK GOWAR, Surgeon Lieutenant-Commander, R.N.V.R.
SURGICAL REGISTRAR, THE MIDDLESEX HOSPITAL; LATE FIRST ASSISTANT IN DEPARTMENT OF THORACIC SURGERY, THE LONDON HOSPITAL

Pulmonary lobectomy is now firmly established as a curative operation in certain cases of bronchiectasis, yet despite the advances in technique and anæsthesia that have been made during recent years, it is still an operation which carries a mortality of from 10 to 20 per cent. It is true that this figure represents a considerable improvement on the earlier results, for Graham (1923) collected the cases reported up to that time and found a total mortality of 52 per cent, but, even so, it is one which it should be possible to lower yet further. Another disturbing factor is that it does not seem possible to forecast which case will go wrong, for, as will be shown later, the mild case without a large amount of sputum is almost as likely to develop one of the most serious complications, i.e., massive collapse of the upper lobe, as is the case with gross disease and much sputum.

The present research was undertaken in an attempt to assess the causes of the post-operative complications of lobectomy and to determine whether any of the aetiological factors could be overcome. The clinical material studied was provided by the cases operated on by Mr. Tudor Edwards and Mr. Price Thomas at the Brompton Hospital between 1929 and 1938.

It is proposed, first, to give a short account of the post-operative complications of lobectomy and then to proceed to a consideration of the aetiological factors involved.

1. Shock.—This is usually proportional to the extent and vascularity of the adhesions which require to be separated at the operation. It may be overcome by the judicious use of rectal or intravenous saline and of blood transfusion during and after the operation. It led to a fatal outcome in a few of the early cases, but is no longer regarded as a likely cause of death. So-called pleural shock has not been encountered on opening the pleura, and it has been suggested that this phenomenon is really due to air embolism. The manipulation of the hilum of the lobe may also result in shock, and O'Shaughnessy (1936) and other workers have consequently advised the injection of novocain subpleurally around the hilum before the tourniquet is applied. The anæsthetic records at the Brompton Hospital, however, show that as a rule the application and tightening of the tourniquet have very little effect on the blood-pressure and pulse, whether spinal or inhalation anæsthetics are being used (*Figs.* 1, 2).

2. Reactionary Hæmorrhage.—Reactionary hæmorrhage may occur from adhesions, or more rarely from the hilar stump. The latter should not occur with

* Being the substance of a Hunterian Lecture delivered before The Royal College of Surgeons of England on February 6, 1939.

modern methods of suturing the stump. Usually there is drainage of 10–20 oz. of heavily blood-stained serum in the first 24 hours after operation. If the bleeding is excessive, it can be controlled by blood transfusion, and it is a routine at the Brompton Hospital to give a transfusion after the operation if adhesions are widespread and vascular, and if excessive oozing is therefore anticipated.

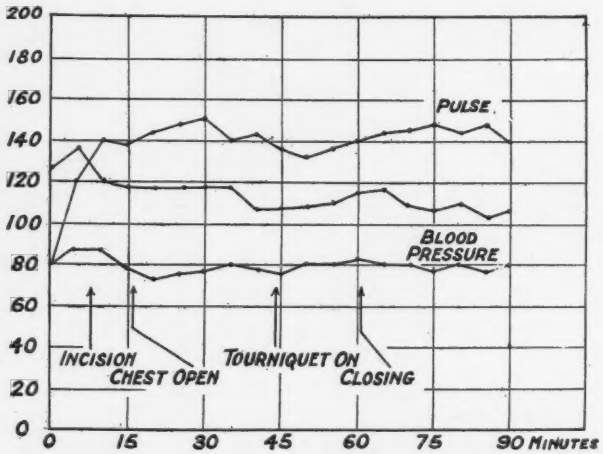


FIG. 1.—Anæsthetic chart from a patient on whom lobectomy was performed under spinal anæsthesia. Note the absence of any appreciable alteration in pulse-rate, respiration, or blood-pressure after opening the pleura or after the application of the tourniquet to the hilum of the lobe. (J. K., No. 30467. Age 21. Bronchiectasis left lower lobe. Upper lobe free. Lower lobe adherent to upper lobe and pericardium.)

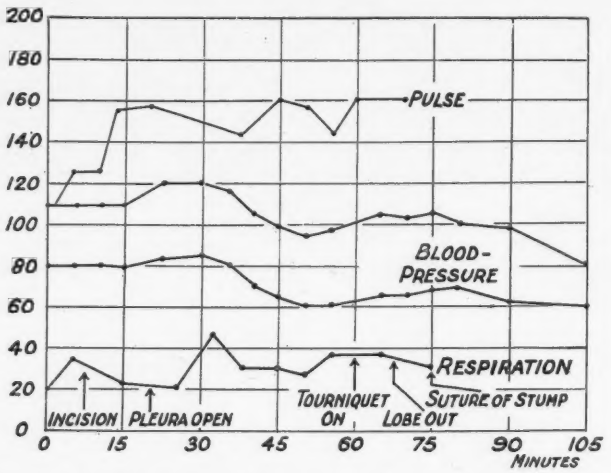


FIG. 2.—Anæsthetic chart in a case of lobectomy under general anæsthesia. (J. L., No. 32760. Age 10. Congenital cyst left lower lobe. Lung adherent..)

3. Tension Pneumothorax.—This occurred as a fatal complication in some of Sauerbruch's cases which were not drained, owing to the early development of a valvular bronchial fistula. This complication, again, is less likely to occur with the modern technique for dealing with the stump, and now that drainage of the pleura is a routine, such a leak would not be likely to lead to tension pneumothorax. Mediastinal emphysema has also been reported, and is due to retraction of an incompletely occluded bronchus into the mediastinum.

4. Embolic Phenomena.—Damage to a branch of the pulmonary vein may lead to the aspiration of air or infected material into the left auricle and may lead to the immediate production of a hemiplegia and to the subsequent development of a cerebral abscess. Dislodgement of an infected clot from the ligated pulmonary vein may also lead to a post-operative cerebral abscess. Recovery from these abscesses is rare, as they are usually multiple, and rupture into a ventricle of the brain or into the subarachnoid space occurs relatively early.

5. Intracardiac Thrombosis.—This has been described by Archibald (1934) and is due to a spreading thrombosis from the ligated pulmonary veins.

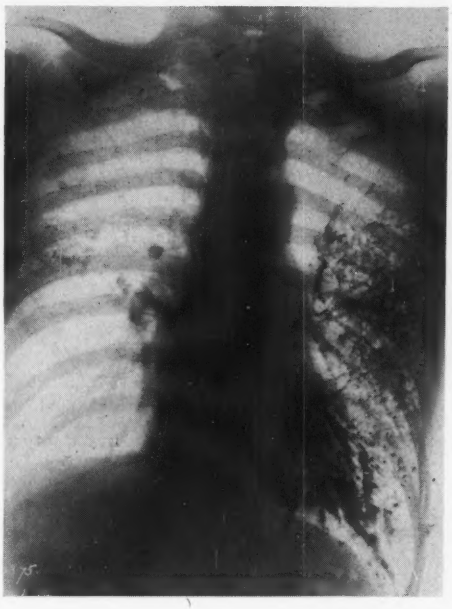


FIG. 3.—Left bronchogram showing bronchiectasis involving lower lobe and lingular process of upper lobe (antero-posterior view).

FIG. 4.—Same case as *Fig.* 1 (lateral view).

6. Massive Collapse of the Remaining Lobe.—This is the most serious of the complications of lobectomy, and will be studied in detail later. It was responsible for over one-third of the total post-operative deaths in the present series of cases.

7. Bronchopneumonia.—Bronchopneumonia is more likely to occur if bronchiectatic areas of lung remain after the operation, and is one of the greatest dangers when operating in the presence of bilateral disease. It also occurs in the other lung as a terminal event in cases of permanent collapse of the upper lobe with suppuration, and is of the aspiration type.

8. Infection.—This may occur :—

a. In the Hilar Stump.—The severity depends on the degree of infection present in the bronchi at the point of division, and is inevitable where the bronchi here are dilated and contain pus. If the infection is severe, sloughing of the stump will occur with the production of a bronchial fistula and possibly of secondary hæmorrhage. Usually, provided that the upper lobe is already adherent or has

re-expanded normally, the infection will remain localized to a basal pleural pocket, but if there is collapse of a free upper lobe, total empyema will result.

FIG. 5.—Bronchogram showing bronchiectasis of left lower lobe.

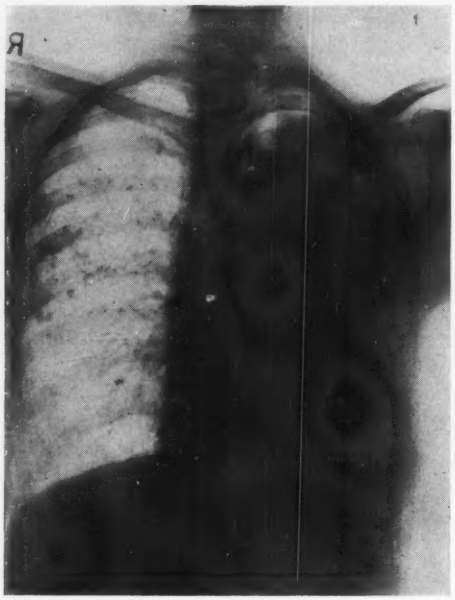


FIG. 6.—Same case as *Fig.* 5 after lower lobectomy. Massive collapse of adherent upper lobe. Note tracheal displacement to affected side. In this case the collapse was permanent.

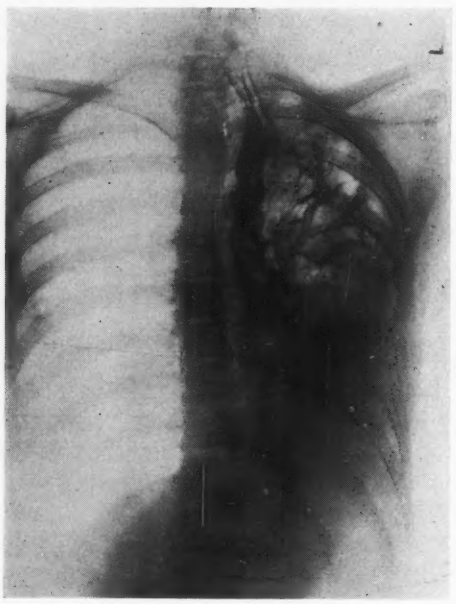


FIG. 7.—Same case as *Figs.* 5, 6. Bronchogram 1½ years after operation, showing bronchial dilatation in upper lobe. There is slight dilatation visible in the pre-operative bronchogram (*Fig.* 5), but the disease appears to have progressed.

b. In the Chest Wall.—Romanis and Sellors (1936) described several cases in which massive necrosis and spreading gangrene of the chest wall and pleura had led to a fatal termination, but serious infection of the wound has been encountered only once in the present series of cases, and then in association with putrid empyema and pericarditis, and it was not itself the direct cause of death.

c. Mediastinitis may occur from infection in the hilar stump, but it is rarely found, provided that external drainage of the stump is adequate.

9. Pericarditis has occurred in a few cases. It is always associated with sepsis in the pleura and is probably caused by direct or lymphatic spread of infection. Operative trauma to the pericardium will naturally make this complication more probable and every effort must be made to avoid such damage.

10. Spread of Bronchiectasis.—It is a moot point whether bronchiectasis is a progressive disease, but in a number of cases in which a left lower lobe has been removed, the lingular process of the upper lobe—the homologue of the right middle lobe—which was slightly diseased before operation, appears to have become more bronchiectatic afterwards. It is probable that in most cases this appearance is fallacious, as it is rarely that the pre-operative bronchogram in such cases shows an adequate filling of the lingular process with lipiodol (*Figs.* 3, 4).

The other way in which spread may occur is following a collapse of the upper lobe, and it is seen in the cases of permanent collapse which do not succumb to infection (*Figs.* 5–7).

In the cases of delayed re-expansion, the bronchi usually remain normal, provided that infection has not occurred.

COLLAPSE OF UPPER LOBE

(*Figs.* 8–13)

To return to the question of collapse of the upper lobe: in an uncomplicated case with free upper lobe, the remaining lobe expands rapidly, is well out in 24 hours, and expansion is complete in from 3 to 5 days. Various factors are necessary to bring about this desirable state of affairs:—

1. A free outlet for fluid and air from the pleural cavity as the lobe re-expands. Rib resection with the provision of a wide-bore drainage tube is much more satisfactory than intercostal drainage, where the tube is liable to become kinked or blocked with clot much more easily. Great care must be taken during the immediate post-operative period to ensure that the tube drains constantly, and this fact must be impressed on the nursing staff.

2. A bronchial tree free from obstruction. Attempts are made to achieve this by pre-operative postural drainage, and during the operation by postural drainage when spinal anæsthesia is employed or by intratracheal suction when inhalation anæsthesia is used.

3. A negative intrapleural pressure maintained by the inspiratory chest movements and the closed (water seal) drainage system. This condition is abolished by the early development of a bronchial fistula or by a loosely fitting drainage tube.

Cases have been classified by Tudor Edwards according to the way in which re-expansion takes place:—

1. Expansion is regular and uniform.

2. Unequal re-expansion may result in the formation of fluid pockets. This

is probably due to the blocking of a few bronchioles. The pockets usually remain sterile and should be treated by aspiration, repeated if necessary (*Fig.* 8).

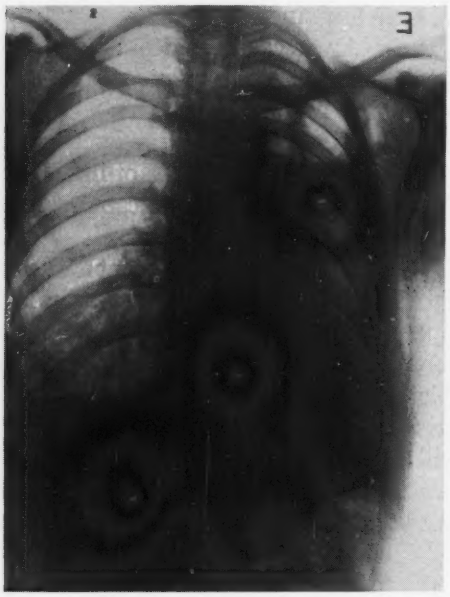


FIG. 8.—Film taken 10 days after a left lower lobectomy, showing unequal re-expansion of upper lobe with formation of fluid pockets. In this case the apex was partially adherent. Aspiration of the pockets was followed by rapid re-expansion.

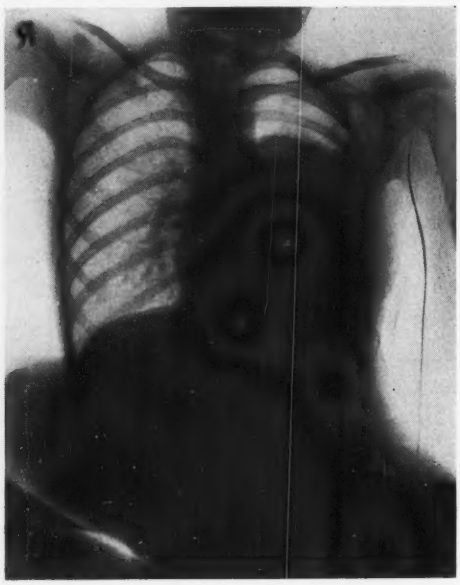


FIG. 9.—Collapse of free upper lobe following left lower lobectomy. In this case re-expansion was complete in one month.

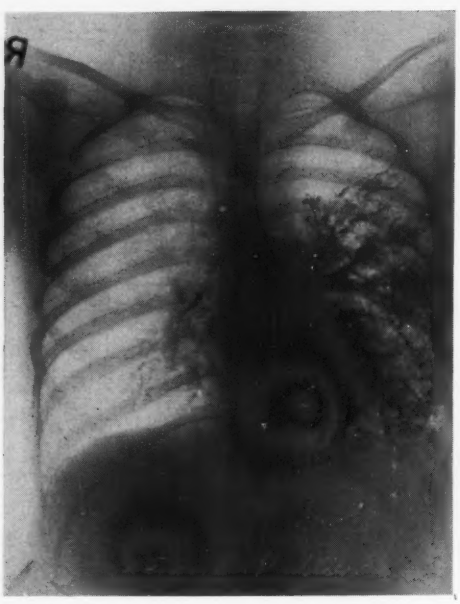


FIG. 10.—Same case as *Fig.* 9. Bronchogram two weeks after operation, showing slight bronchial dilatation in lingular process.

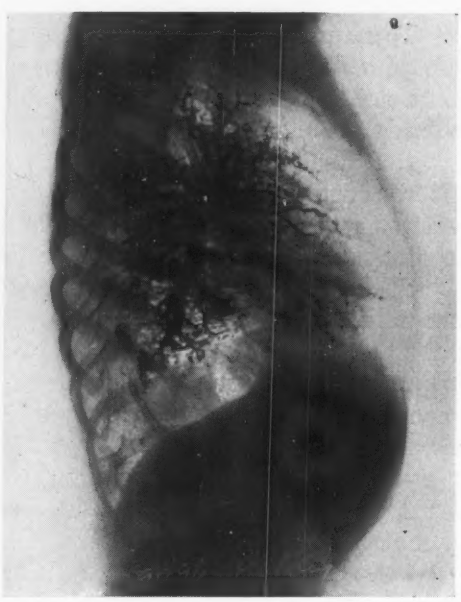


FIG. 11.—Same case as *Figs.* 9, 10. Bronchogram (lateral view).

3. Secondary collapse may occur owing to the early adhesion of the base and the cutting off of the upper pocket from the drainage opening. The pressure of fluid accumulating in the upper pocket causes a collapse of the upper lobe. Treatment consists in pushing the drainage tube up into the upper pocket, if the sealing-off is recognized early before the lobe is firmly stuck. Alternatively, an intercostal drain may be inserted higher up, or repeated aspiration may be carried out. A secondary collapse may also follow the early development of a bronchial fistula before the lobe has become stuck out.

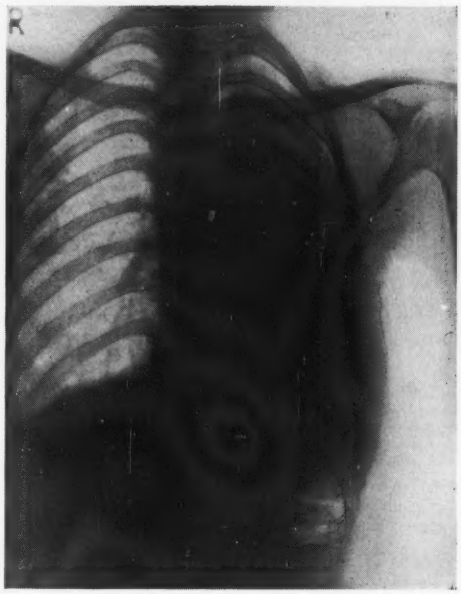


FIG. 12.—Massive collapse of adherent upper lobe following left lower lobectomy.

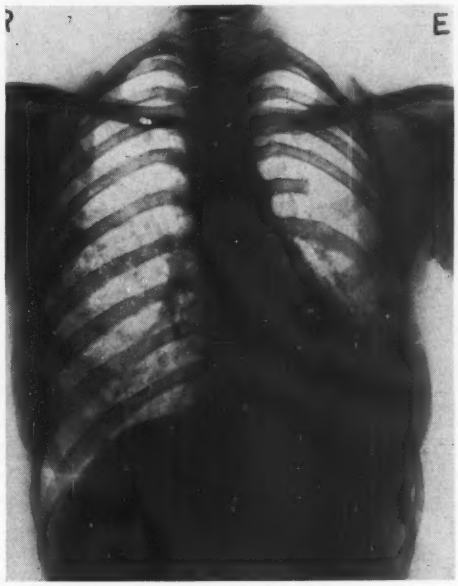


FIG. 13.—Same case as *Fig.* 12, but taken 12 days later, showing complete re-expansion.

In some cases a massive collapse has been observed to occur several days after the operation. In these cases it is suggested that swelling of the hilar stump occurs, leading to œdema and obstruction of the upper lobe bronchus. Re-expansion is usually rapid.

4. Delayed expansion, due to aspiration of purulent material into the larger bronchi of the lobe only. This group is best treated by bronchial aspiration.

5. True massive collapse due to aspiration of secretions into the smaller bronchi and bronchioles (*Fig.* 14). If the patient is unable to expel the plugs a suppurative pneumonitis results. For this type the mortality is very high, and lobectomy is the only procedure which is likely to be successful (*Figs.* 15–17). With the realization of the importance of getting the upper lobe fully expanded as quickly as possible, attempts have been made to accelerate the process by actually blowing it out with oxygen at the end of the operation, or by aspirating the air from the pleural cavity. Both these measures are open to the objection that if secretions are present in the upper lobe bronchus, they will be sucked into the bronchioles and will thus be more liable to produce a collapse of the lung. To overcome this difficulty, bronchoscopic aspiration at the end of the operation has been advocated by Roberts.

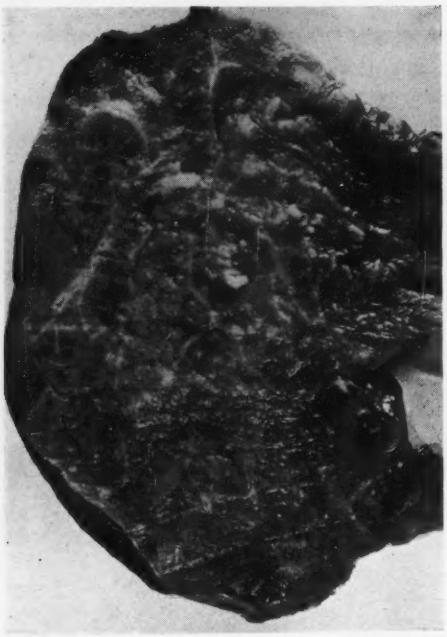


FIG. 14.—Left upper lobe removed for massive collapse 3 days after left lower lobectomy. The operation specimen shows an airless lobe with plugs of mucopus in the cut bronchi and bronchioles.

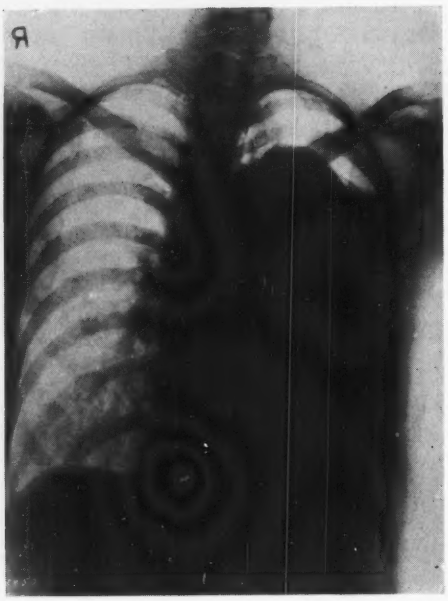


FIG. 15.—Collapse of upper lobe following left lower lobectomy. Note the fluid level indicating that the drainage track has become closed off.

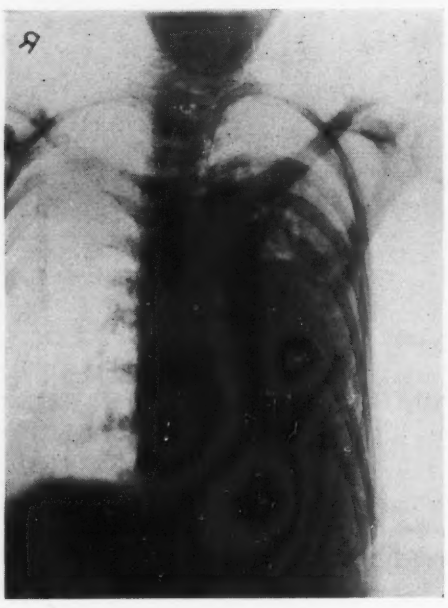


FIG. 16.—Same case as *Fig.* 15. Film taken about 4 weeks after lobectomy, showing evidence of cavitation in the lobe. This patient died of suppurative pneumonitis 6 weeks after operation.

FIG. 17.—Same case as *Figs.* 15, 16. Post-mortem specimen of left upper lobe, showing extensive cavitation in the unexpanded lung tissue.

FACTORS IN THE CAUSATION OF COLLAPSE

Table I is an analysis of the lobectomies performed at the Brompton Hospital by Mr. Tudor Edwards and Mr. Price Thomas since 1929. As the present research is concerned only with bronchiectasis and allied conditions, all cases of neoplasm have been excluded. This table shows the factors which have been thought to be concerned in the non-expansion of the upper lobe.

Table I.—Pulmonary Lobectomy: Incidence of Post-operative Collapse

Total Incidence	51 in 154 cases (33 per cent)	
Seasonal	April–Sept.	32 in 93 cases (34·4 per cent)
	Oct.–March	19 in 61 cases (31·1 per cent)
Bronchography-lobectomy interval	Less than 2 weeks	12 in 39 cases (30·8 per cent)
	2 weeks–2 months	18 in 40 cases (45·0 per cent)
	Longer than 2 months	21 in 75 cases (26·7 per cent)
Anæsthetic	Spinal	23 in 60 cases (38·3 per cent)
	Inhalation	25 in 88 cases (28·4 per cent)
	Spinal + inhalation	3 in 6 cases (50·0 per cent)
Quantity of sputum	Less than 2 oz.	31 in 95 cases (32·6 per cent)
	More than 2 oz.	20 in 59 cases (33·9 per cent)
Residual bronchiectasis	Present	23 in 64 cases (34·4 per cent)
	Absent	28 in 90 cases (31·1 per cent)
Adherence of remaining lobe	No adhesions	34 in 70 cases (48·6 per cent)
	Partially adherent	8 in 33 cases (24·2 per cent)
	Adherent	9 in 51 cases (17·7 per cent)
Anatomical site of disease	Right side	10 in 57 cases (17·5 per cent)
	Left side	41 in 97 cases (42·5 per cent)

1. Mechanical Factor.—It will be seen that collapse is a much more common and more serious complication in cases where the lobe is free. A possible explanation of this is that the free non-expanded upper lobe is not so well able to expel the secretions from its bronchi during coughing. Owing to the presence of the drainage tube, the raising of the intrapleural pressure during the expulsive effort forces air out through the water-seal bottle, and thus prevents a positive pressure being exerted on the upper lobe. Secretion may even be coughed across into it from the opposite lung. If the upper lobe is adherent this factor does not, of course, operate. Another factor which is stressed by Tudor Edwards is that the free upper lobe contains only a small volume of air, thus again reducing the expulsive force of the cough, which depends on the volume of air distal to the plug of secretion in the bronchus.

2. Site of Disease.—Massive collapse has been encountered nearly two and a half times as frequently after left-sided lobectomy as after operations on the right side. This is only partly accounted for by the larger number of free left upper lobes met with—right side, 10 cases of collapse in 5 of which the upper lobe was free (50 per cent); left side, 41 cases with 29 free lobes (70·7 per cent). There is a possible anatomical explanation for the greater incidence of collapse on the left

side: the left main bronchus is longer, narrower, and runs more obliquely than the right; in consequence of its low origin, the left upper-lobe bronchus and its branches all tend to have an upward direction (Nelson, 1934). Secretions are therefore more likely to collect in the left upper-lobe bronchi during the operation, and, owing to the mechanical disadvantages associated with the drainage of these bronchi, retention is more liable to occur and bronchial obstruction becomes more probable.

3. Nervous Factor.—Another possible factor is a reflex nervous one. Theoretically, operative trauma to the upper lobe might lead reflexly to a massive collapse. Trauma is, of course, likely to be greater, or at any rate applied to a larger area of the upper lobe when it is free. There is, however, no experimental evidence that massive collapse can be produced by stimulation of afferent nerves in the lung or pleura, and there is very little evidence for the existence of such a reflex. In addition, Band and Hall (1931) came to the conclusion that there was no experimental evidence that massive collapse of the lung could be brought about by stimulation of peripheral nerves.

4. Extent of Disease.—It is a striking thing that the amount of sputum and the presence of residual bronchiectasis appear to have no relation to the incidence of collapse.

5. Pre-operative Use of Iodized Oil.—Belsey (1937) analysed the lobectomies done at the Brompton Hospital by Roberts and Brock, and his findings correspond very closely with those in the present investigation. He comments on the greater frequency of collapse in more recent cases, and suggests that, as there has been no radical alteration in technique in the last few years, the difference may be due to the more recent and more liberal use of iodized oil in the investigation of the patients before operation. In the early cases, bronchography was used merely to confirm the clinical diagnosis of bronchiectasis, and the remainder of the lung was rarely filled adequately. In more recent cases, the importance of making a complete bronchographic examination of the lung has been realized, and the oil has been used much more extensively. Belsey found that collapse was more common in those cases in which the interval between bronchography and lobectomy was less than eight weeks, than in those with a longer interval. As a considerable amount of oil can usually be demonstrated in the lungs at the time of lobectomy, it was thought that its presence might in some way render the lobe more liable to collapse. Against this theory, however, is the fact that contralateral collapse of a lobe is extremely rare—it occurred on only 2 occasions in the present series of 154 cases, with 51 collapsed lobes, and in one of these the affected lobe was bronchiectatic and the retention of secretion was probably the deciding factor.

One frequently finds just as much residual lipiodol on the unoperated side (*Fig.* 18), and one would expect that if its presence were an important factor, contralateral collapse would be much more common than it is.

Effect of Iodized Oil on Lung.—Certain earlier workers had reported changes in the lungs of animals following the intrabronchial injection of iodized oil. Thus Sato (1929) reported that it was absorbed by the bronchial epithelium, and found it in the bronchial cartilage cells, while Kotatsu (1929) described proliferation of the bronchial epithelium with the formation of folds and adenomatous masses. Fried and Whitaker (1927) found desquamated epithelial and septal connective-tissue cells gathered together in certain areas to form tumour-like masses. Weinberg

(1923) described massive atelectasis, which might be followed by pneumonitis, but in these experiments it is probable that a relatively large quantity of oil was injected and that a massive alveolar filling occurred.

It appeared from these reports that there might be a histological basis for the apparent greater frequency of collapse shortly after bronchography, inasmuch as the changes described led to a narrowing of the bronchial lumen and thus made blockage more likely. A series of rabbits was therefore injected with neohydriol. The animals were anæsthetized with intravenous nembutal, and the oil injected through a fine rubber catheter inserted into the trachea under direct vision. An attempt was made to confine the oil to one lung by turning the animal on the right side before the injection was made. A radiograph was taken to determine the distribution of the oil, and the animals were then killed at intervals of 2–42 days afterwards. The lungs were removed and preserved in formol-saline. After a further X-ray examination to see how much oil remained in the lungs, they were examined by Dr. J. R. Gilmour, of the London Hospital. The histological findings were briefly :—

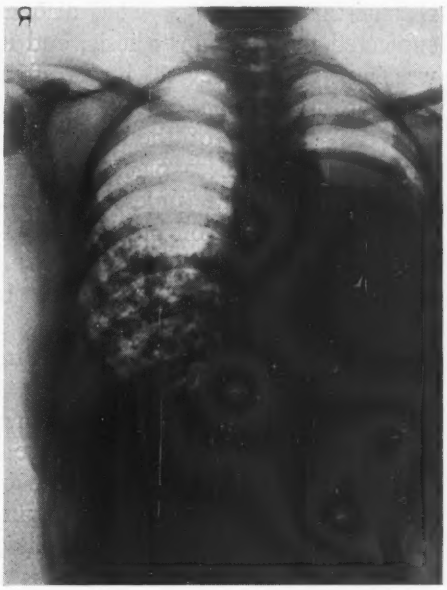


FIG. 18.—Collapse of left upper lobe following left lower lobectomy. Note the amount of residual lipiodol present on the right side.

1. Accentuation of the interstitial pneumonia previously present (in captive rabbits).

2. No significant areas of atelectasis.

3. Formation of epithelioid-cell nodules in the walls of alveoli and terminal bronchioles, probably derived from the interstitial cells.

4. No evidence of proliferation of bronchial epithelium.

5. Phagocytosis of neohydriol very scanty : no evidence of removal of neohydriol from the lung by macrophage migration.

An interesting fact emerged in connexion with the epithelioid-cell nodules. They were found in only one of six animals injected with non-viscous neohydriol, whereas all the animals injected with viscous neohydriol showed nodules. It will be seen that these findings did not correspond very closely with those of previous workers, and it was not considered that the histological changes demonstrated were likely to predispose to collapse. Varying quantities of oil were found lying free in the alveoli and bronchioles : only traces were intracellular. It is therefore possible that the oil might act mechanically in the maintenance of collapse by making the alveolar walls sticky and offering a resistance to expansion. This explanation would, of course, only apply to the cases with a free upper lobe.

It appears that the oil is eliminated from the bronchus almost entirely as a result of coughing. It is therefore desirable to get rid of it as soon as possible after bronchography by postural drainage. The large amount of oil retained in the rabbit's lung is probably due to the fact that the rabbit does not cough.

6. Anæsthesia.—With regard to the other factors, collapse appears to be more common when spinal anæsthesia has been employed. It seems likely that the anatomical factors already considered play an important part here, for it has been customary to adopt an increased lateral Trendelenburg position during an operation under spinal anæsthesia, in order to counteract the fall of blood-pressure and to facilitate the escape of secretions from the trachea. At the same time, however, this position aggravates the mechanical difficulties which interfere with drainage of the upper-lobe bronchi, and secretions are more likely to flow back into them and be retained; any undue manipulation of the diseased lobe during the operation will be likely to express secretions into the main bronchus, and will increase the risk of this occurring. The incidence of collapse was greatest in the first group subjected to spinal anæsthesia, and it is probable that this was because the patient was kept flat for several hours after the operation and was raised only gradually to a sitting position. As Nelson pointed out, it is in a sitting (Fowler) position that the drainage of the upper-lobe bronchi is most assisted by gravity. It is therefore desirable to place the patient in a semi-sitting position immediately on return to the ward (unless his general condition contra-indicates it) and to raise the foot of the bed on blocks to assist venous return from the limbs, in an attempt to prevent a fall of blood-pressure. The incidence of collapse appears to have diminished since this technique has been adopted, and there seems to be no greater incidence of headache afterwards. The spinal group comprises most of the cases operated on since 1935, and therefore includes the cases in which a more complete bronchography has been done. At the same time, the lingular process or the right middle lobe has been removed more frequently with the lower lobe, and this fact makes post-operative œdema of the hilar stump more likely. It is thus seen that several of the possible factors are operating together and it would be unwise to pay too much attention to the figures in *Table I.*

7. Pleural Adhesions.—It has long been realized that lobectomy performed in the presence of a free pleura is a much more hazardous procedure than when the pleural space is obliterated by adhesions (*Table II*). Thus, Robinson (1917)

Table II.—Post-Lobectomy Collapse of Remaining Lobe

Speed of Re-expansion	*Lobe Free*	*Partially Adherent*	*Adherent*
0–2 weeks	2	3	4
2–6 weeks	11	4	3
6 weeks–6 months	3	1	0
Longer than 6 months	5	0	1
Permanent collapse	13	0	1
Totals	34	8	9

Fate of cases with permanently collapsed lobes

Deaths (9 in 51 cases = 17·6 per cent = 5·84 per cent of all cases).—
- 2 from secondary hæmorrhages (one after removal of collapsed lobe).
- 5 from suppuration in collapsed lobe with or without other complications.
- 1 from cerebral abscess—the case in which lobe was adherent.
- 1 from spontaneous pneumothorax, tuberculous, on contralateral side.

Recoveries.—
- 2 with conservative treatment—both now have gross upper-lobe bronchiectasis.
- 2 after removal of infected upper lobe.
- 1 after thoracotomy and packing of chest—lobe removed later on account of gross bronchiectasis.

commented on this fact, and Graham (1923) wrote, "Any procedure which will permit of the easy and safe creation of firm adhesions between the unaffected portion of the lung and the chest wall will serve greatly to reduce the mortality of the operation, for the double benefit of a minimum of pleural cavity to be infected, and a minimal amount of respiratory disturbance during and immediately after the operation, will result."

It was not realized, however, that the important factor is not the total empyema, but massive collapse of the upper lobe, for, as Tudor Edwards pointed out in 1936 at a meeting of the Society of Thoracic Surgeons, the collapse is the primary condition and total empyema only a secondary complication of this. As the table shows, collapse is considerably more common and more dangerous when the lobe is free. It is thus desirable, before performing lobectomy, to determine whether the lung is free, by attempting to induce a pneumothorax, and, if the upper lobe is free, measures should be taken to create adhesions between it and the chest wall. Various attempts have been made to discover the ideal method of doing this, and the methods fall into two groups :—

1. Extrapleural—the exposure of the parietal pleura and the application of irritants such as an iodine pack to it. This method is successful in forming localized adhesions over a lung abscess, but is obviously not available for the production of widespread adhesions, as it would entail too extensive an exposure and would rank as a major procedure.

2. Intrapleural—methods have included the injection of chemical irritants, the scarification of the pleura, the introduction of solid foreign bodies such as wire, tape, etc., and the introduction of irritant gases and powders.

Two methods have been tried out extensively :—

a. Lilienthal (1932) advocated thoracotomy and the scarification of the parietal pleura by means of gauze dipped in tinct. iodi, while Alexander (1933) recommended the same procedure, using dry gauze. This method generally led to the production of effusion, and pocketing was common. Tudor Edwards (1939) scarified the parietal pleura with dry gauze introduced on a pair of forceps through an intercostal cannula, but in spite of vigorous rubbing, adhesions were inconstantly formed.

b. Bethune (1935), as a result of successful experimental work, insufflated iodized talc powder into the pleural cavity, through an intercostal cannula under thoracoscopic control, and reported very good results from the method. It has the advantage that it ranks as a minor procedure and, provided that care is taken to sterilize the powder efficiently, it is devoid of risk. It does not, as a rule, lead to fluid formation, but in a few cases the adhesions are patchy and fluid loculi are formed.

According to Bethune, the ideals for any method of creating adhesions are : (1) it should be a selective upper lobe irritant, to be easily applied in a pneumothorax space without opening the chest ; (2) the irritant should penetrate into the crevices of the pleural cavity ; (3) it should not depend on special posture to retain the irritant over any selected area of pleura ; (4) it should be non-absorbable to avoid toxic effects ; (5) a short self-limiting pleural reaction should be set up, if possible without fluid formation, which would rapidly subside, leaving the adhesions as harmless sequelæ.

Artificial Pleurodesis.—While working at the Buckston Browne Research Farm, the author set out to investigate the methods of producing adhesions. Although

good results were claimed for poudrage, its results had not been uniformly good in cases treated at the Brompton Hospital. It was therefore thought desirable to find a mildly irritant solution which could be introduced into the pleura more simply than could the powder.

Technique: Rabbits were used for this work. After being anæsthetized with intravenous nembutal, the animal's right chest was shaved and it was placed on its left side on a sandbag. An initial pneumothorax needle was inserted into the right pleura and its position confirmed by the oscillation of the manometer of a pneumothorax apparatus. The apparatus was then clipped off, a syringe attached to the A.P. needle, and the requisite fluid injected. No air was admitted by this technique. The animal was laid on the right side until it recovered from the anæsthetic. After intervals of 2–14 days, the animals were killed and the pleural cavity examined. *Table III* shows the large variety of substances used. In common with Bettman

Table III.—PLEURODESIS: FLUIDS EMPLOYED TO CREATE ADHESIONS

Bacterial suspensions:
Streptococcus vaccine, Staphylococcus vaccine } 1000–10,000 m. per c.c.
Starch emulsion.
Aleuronat emulsion.
Colloidal calcium (Crooke's), 1–2000 to 1–4000.
Colloidal silica (Crooke's), 1–2 per cent.
Blood, autogenous, citrated and whole.
Glucose, 50 per cent.
Glucose broth, 25 per cent.
Broth—double and single strength.
Glycerol.

Irritant solutions

Sodium morrhuate	1–5 per cent	Quinine + Urea HCl	1 per cent
Tannic acid	1–5 „ „	Quinine + Urethane	5–20 „ „
Formaldehyde	1 „ „	Lugol's iodine	
Salicylic acid	½–1 „ „	Tinct. iodi	1–2·5 „ „
Sodium salicylate	10–40 „ „	Proliferol	½ or full strength

(1926), Hirschfeld, Cohen, and Stout (1933), and Alexander, it was found that the stronger irritant solutions led to the production of large effusions with some elongated bands, and frequently caused damage to the lung parenchyma. Weaker and less irritant solutions produced inconstant adhesions and were frequently absorbed, leaving no trace in the pleura.

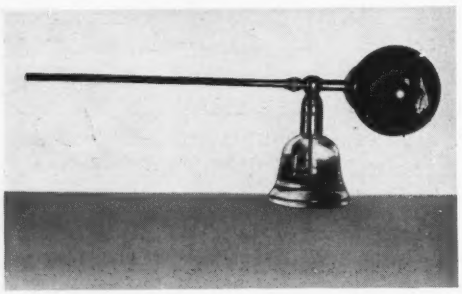


FIG. 19.—Return-air powder blower (G.-U. Mfg. Co.).

Poudrage.—The failure of this search for the ideal sclerosing fluid led to a repetition of Bethune's work on goats, and his good results were confirmed. The goat was anæsthetized by intraperitoneal nembutal, the right chest prepared, and a pneumothorax induced —500 c.c. was the average volume of air for an animal of 25 kg. The pleura was then inspected through a thoracoscope and ½ per cent iodized talc powder blown in by means of a return-air powder-blower (*Fig.* 19). The nozzle of the instrument was directed on to the surface of the upper lobe and powder

blown in until it was thickly covered and had a sugar-icing appearance. It was found that 2·5 g. was an average dose. The pneumothorax was then aspirated completely, re-expansion confirmed by X rays, and the animal left for 2–8 weeks. After this time, thoracotomy was performed: it was found that the upper lobe was uniformly and directly stuck to the chest wall, but could be separated fairly easily up to 10 weeks after the poudrage.

If the powder was directed on to the upper lobe only, it was found that the lower lobe remained practically free. The secret of getting a uniform adherence appeared to depend on a uniform and sufficiently thick application of the powder.

The ideal time for lobectomy is 3–8 weeks afterwards, while the adhesions are still soft. Tudor Edwards is now using the method on his cases, and confirms these good results. Pleural pain may be complained of after poudrage, when the two pleural surfaces come in contact, but it does not often last longer than one hour. No other complications have been encountered.

In conclusion it is suggested that the risks attending lobectomy might be reduced by:—

1. Allowing a prolonged period of postural drainage before operation in order to reduce the quantity of sputum present.

2. Encouraging the elimination of neohydriol after bronchography, and if there is much X-ray evidence of retention, allowing an interval of at least 2 months between bronchography and lobectomy.

3. Operating only with the upper lobe adherent to the chest wall and, if necessary, performing a preliminary pleural poudrage to effect this.

4. In the matter of anæsthesia, it appears that, using the post-operative technique already indicated, spinal anæsthesia is at present the most satisfactory.

5. Provision of an adequate drainage tube and the exercise of great care to see that it does not become blocked. If it does, then the necessary steps should be taken at once to get the pleura draining again.

6. Encouragement of postural drainage of the upper lobe by placing the patient in a semi-sitting position as soon as possible after the operation.

7. Encouragement of re-expansion of the upper lobe by means of breathing exercises, and possibly by intermittent inhalations of CO_2 and oxygen.

It is a pleasure to express my gratitude to Mr. Tudor Edwards, at whose suggestion this research was undertaken, for his constant encouragement and advice. He has very generously allowed me to study his cases and to incorporate many of his views in this paper. I wish also to thank Mr. Price Thomas for allowing me to study his cases at the Brompton Hospital; Professor John Beattie, Director of Research at the Royal College of Surgeons, under whose direction the experimental work has been performed; and Professor James McIntosh and Dr. P. N. Panton for providing facilities for experimental work in the Pathological Departments of the Middlesex Hospital and of the London Hospital respectively, in addition to those provided by the Royal College of Surgeons. I should like to record my appreciation of the interest taken in my research by Sir Arthur Keith, Master of the Buckston Browne Research Farm, during the time I was resident at Downe. My thanks are due, also, to the Medical Research Council for a personal grant-in-aid during this time.

It is hoped to publish the experimental work in greater detail at a later date.

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OSTEITIS OF THE METATARSAL SESAMOID

INCLUDING A REPORT OF A CASE OF ACUTE PYOGENIC OSTEOMYELITIS

By RODNEY SMITH

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THE metatarsal sesamoid but rarely exhibits the pathological lesions which are common in other bones. The only disease occurring with any frequency is a chronic one, the main symptom of which is pain in the affected sesamoid. The pathology of this condition has for many years been the subject of much dissension among authorities, and this fact accounts for the diversity of names by which it is known. It has, at different times, been referred to as 'typical disease' of the sesamoid, osteochondritis, juvenile necrotic osteopathy, sesamoiditis, and Köhler's or Schlatter's disease of the sesamoid. Radiologically the affected bone presents a stippled, spotted appearance which Schütz and Renander attributed to the occurrence of areas of necrosis in the marrow and trabeculæ. Finochietto referred to this as the 'leopard-skin' appearance, and likened the condition to Schlatter's disease. Fracture of the sesamoid has also been described as a cause of sesamoid pain.

Now it is very often found that the metatarsal sesamoid is normally divided into two or more ossicles, and Schütz gave it as his opinion that only in the presence of this division does the pathological condition described arise. Inge and Ferguson, however, state that the bone ossifies at the age of 8 to 11 years from multiple centres and that division of the sesamoid, due to failure of union of these centres, does not predispose towards sesamoid pain. In their series of cases they came to other conclusions of importance, namely:—

1. That fracture is very rare and should not be diagnosed unless a previous radiograph shows no division of the bone at the line of suspected fracture. I would suggest that, in an adult, should union eventually occur, the existence of a fracture may be presumed, even in the absence of a radiograph taken before the onset of sesamoid pain.

2. That actual bony changes of the variety known as Köhler's or Schlatter's disease must be very rare. None of the cases of sesamoid pain which they encountered presented a pathology of this kind, the cause of the pain being bursitis, luxation, or arthritis.

Whatever the precise pathology, this chronic condition, though uncommon, is not of extreme rarity. Acute pyogenic osteomyelitis of the sesamoid, however, is almost unknown and only 2 authenticated and 2 doubtful cases have been recorded. In 1928 Lange recorded a case of sesamoiditis proceeding to suppuration, while in 1935 Knut Bennet described a case of embolic pyogenic osteomyelitis of the sesamoid in a boy of 12, and two other similar cases in which the pathology

was not quite certain. The case described below is of great interest, then, because, being an undoubted case of acute osteomyelitis of the sesamoid, it appears to be only the third recorded.

CASE REPORT

S. G., a little girl of 13, was admitted to hospital in September, 1940, giving the following history: Five months ago, at the seaside, she bruised the plantar surface of her left foot against a rock. There was no subsequent history of trauma. Two months later, in June, she was seized one afternoon with an acute pain at the base of the big toe of her left foot. The pain was very severe and caused her to weep. The foot was red and swollen in the region of the heads of the first two metatarsals. Next day there was no reduction in pain, and the child also had a severe sore throat. There was no history of any other focus of infection. When seen by her doctor, the child appeared very ill, was in great pain from her foot, and had a temperature of 105°. She was kept in bed and her throat cleared rapidly, but the pyrexia and the pain, redness, and swelling of her foot persisted. After one week she was admitted to the local hospital where X-ray pictures of both feet were taken and appeared normal (*Fig.* 20). Even now, in the light of subsequent events, one cannot say

FIG. 20.—Radiographs showing apparent normality of both feet.

that this radiograph shows any abnormality. In each foot the sesamoid is shown to be tripartite, consisting of a single lateral and a double medial ossicle.

Soon after admission to hospital a yellow blister appeared on the dorsum of the foot between the heads of the first and second metatarsals. After 48 hours this burst, and discharged bright yellow pus. The pain thereupon became much easier and the pyrexia subsided. The sinus was further enlarged by a superficial incision, and after three weeks the child was allowed to return home. The purulent discharge was becoming less copious and the sinus was thought to be healing. Soon after her return home she began to have a little pain in the sole of her foot. This became red and tender at a point between the middle of the shafts of the first and second metatarsals, and a fluctuant swelling appeared. This was incised and discharged pus which appeared similar to that still discharging from the original sinus.

A further radiograph was taken and was thought to show no abnormality. Unfortunately, it was not compared with the previous picture. Actually, if these two are compared, it can be seen that there was osteolysis of the lateral sesamoid, which had become dislocated and displaced proximally (*Fig.* 21). Both of the sinuses continued to discharge pus, and in September the child was readmitted to hospital, where two further radiographs were taken, on the 14th and the 25th of that month.

FIG. 21.—Radiograph showing osteolysis of lateral sesamoid, which had become dislocated and displaced proximally (cf. *Fig.* 20).

When I first saw her at the end of September, she appeared to be in good health, was apyrexial, and had no pain. On examining her foot, there were two sinuses, one on the dorsum between the heads of the first and second metatarsals, the other on the sole between the mid-points of the first and second metatarsals. There was a little tenderness to deep pressure on the sole over the shaft of the first metatarsal. Movements of the ankle and toes were normal and painless. Each sinus was discharging a little yellow pus. This was cultured and a pure culture of *Staph. aureus* was grown. The radiographs were then examined. Those taken on Sept. 14 and 25 (*Figs.* 22, 23), showed the lateral sesamoid to have become completely detached and to be lying between the proximal ends of the shafts of the first and second metatarsal bones. In *Fig.* 22 it can be seen that a tiny abscess had formed inside the bone, and in *Fig.* 23 that further loss of bone had resulted in this abscess discharging spontaneously. There was also some periostitis of the shaft of the first metatarsal, against which the sesamoid was lying.

Under general anæsthesia an Esmarch tourniquet was applied, each sinus was laid open, and the first interosseous space was explored. On laying open the sinus on the sole of the foot, the necrosed sesamoid was found lying free in a pocket of pus. The sinus on the dorsum of the foot was found to lead to

FIG. 22.—Radiograph showing the lateral sesamoid completely detached and lying between the proximal ends of the shafts of the first and second metatarsal bones. An abscess has formed within the bone.

FIG. 23.—Radiograph showing further loss of bone, which has resulted in the abscess discharging spontaneously.

the same pocket through a track passing between the necks of the first and second metatarsals. After removal of the necrosed sesamoid, the track was lightly packed with ribbon gauze and a plaster was applied to immobilize the foot and hallux. The plaster and packing were changed after ten days and again ten days later. After a further ten days, both wounds were practically healed and immobilization with plaster was discontinued. Healing rapidly followed.

My thanks are due to Dr. J. V. Sparks for permission to publish the excellent radiographs of this most interesting case.

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COXA PLANA

WITH SPECIAL REFERENCE TO ITS PATHOLOGY AND KINSHIP *

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THE subject of coxa plana presents much for investigation and discussion; the aspects most considered here will be its pathology and its place among diseases; that is its nature and kinship. Some consideration of allied conditions elsewhere in the body assists an understanding of the hip condition.

A short paper forbids a critical consideration of the views expressed; a necessarily dogmatic exposition does not imply a sense of finality in the writer's mind.

TERMINOLOGY

Logically the term 'coxa plana', a morphological description, should apply to all cases of flattening of the femoral head, whatever the pathology. Waldenström, who suggested the name, added a qualification—essentialis, osteomyelitica, or tuberculotica; this classification excludes flattening of the femoral head in such conditions as congenital subluxation of the hip. 'Coxa plana essentialis' was his synonym for osteochondritis juvenilis of the hip. In his writings he has used the term coxa plana almost exclusively in the sense of coxa plana essentialis, and his usage will be followed here. For the pathological process the unsatisfactory but customary term 'osteochondritis juvenilis', or more briefly 'osteochondritis', will be used. This was coined originally for the condition in the hip. When a condition elsewhere in the body shows pathological evidence of kinship we will conclude provisionally that it may properly be considered an example of 'osteochondritis'; when pathological evidence is the reverse, we will conclude that this name is improperly applied; when pathological evidence is wanting, we will remain undecided but with some bias in favour of the conclusions which a critical consideration of the radiological and other findings may suggest.

GENERAL AETIOLOGICAL FACTORS

Coxa plana may occur at any age between 2 and 18 years, and about three-quarters of the patients are boys. In about 10 per cent both hips suffer, though almost never synchronously. Some supposed familial instances are unsubstantiated, but there are 3 satisfactory reports of examples in siblings.

A history of trauma varies in different statistics from 14 per cent to over 50 per cent. The interval between injury and the onset of symptoms also varies greatly.

* The summary of an address introducing a discussion at a meeting of the British Orthopædic Association, October, 1938, and based on an essay submitted for the Robert Jones Prize of the Association.

The writer has followed the condition in a child with congenital syphilis, but this is exceptional.

A small proportion of cases, at first indistinguishable from coxa plana essentialis, proceed after six to twelve months to manifest tuberculous arthritis. The writer considers these cases true examples of osteochondritis juvenilis, the tuberculous arthritis being a non-specific exciting factor, just as polyarticular arthritis or reduction of a dislocation occasionally leads to osteochondritis. A possible mechanism will be suggested later. These cases of osteochondritis juvenilis in the latent stage of tuberculous arthritis must be distinguished from those instances of flattening of the femoral head secondary to typical tuberculous arthritis without any stage having a true radiological resemblance to osteochondritis.

Table I shows hip conditions which have been reported in association with coxa plana.

Table I.—HIP CONDITIONS ASSOCIATED WITH COXA PLANA.

DISLOCATION	Congenital	Same hip—reduced (many cases)	
		Opposite hip	reduced (1 case)
			unreduced (2 cases)
	Traumatic—reduced (a few cases)		
COXA VARA	Infantile (1 case)—opposite hip		
	Rickety (2 cases)—both hips		
	Slipped epiphysis (1 case)—one hip (both showing coxa plana)		
OSTEOCHONDRITIS OF OPPOSITE HIP	Dissecans (2 cases)		
	Juvenilis (many cases)		
ARTHRITIS	Acute		
	Chronic		

PATHOLOGICAL CHANGES

The writer has not had occasion to operate in the active stage of coxa plana, but has made pathological observations on the supposedly kindred conditions affecting the metatarsal heads and semilunar bone. The pathological changes will therefore be considered under two headings: (1) the pathological changes as determined by observations on the hip by other workers; and (2) the pathological changes found in conditions of presumed similar nature elsewhere.

Bacteriological observations may be dismissed by saying that organisms have been obtained in a minority of instances and have varied in character.

1. Pathological Observations on the Hip.—

The principal histological changes fall on the epiphysial nucleus, and brevity demands description of these alone. Complex changes have been described, but, if the ordinary rules of pathological interpretation are followed in studying the original papers, a clear and definite picture can scarcely fail to emerge. The most

characteristic change is the presence of areas of gross destruction, in which the trabeculæ have disappeared and only debris remains. These areas are usually subchondral in situation. Their contents may calcify. Young connective tissue is seen invading the necrotic areas and tends to lay down osteoid tissue and cartilage. In association with this invading phagocytic and regenerative tissue, marrow fibrosis is found in the contiguous areas of the epiphysial nucleus.

2. The Pathological Changes found in Conditions of Presumed Similar Nature at other Sites.—

a. Changes in the Second or Third Metatarsal Head (Freiberg's Disease, or Köhler's Second Disease).—Only the active stage will be described. This seems to be confined, like that of coxa plana, to the growing period. Symptoms becoming manifest for the first time in adult life are probably mechanical or arthritic in origin, the active stage having passed unnoticed in childhood or adolescence.

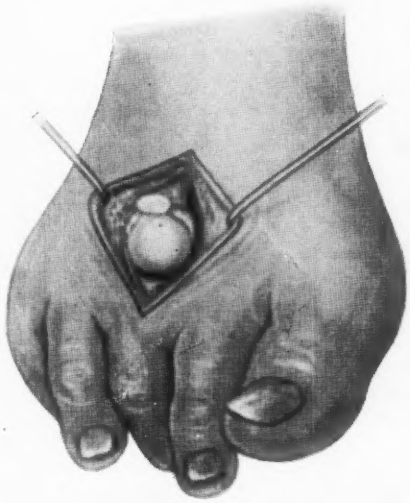


FIG. 24.—Appearances found at operation in a case of osteochondritis of the third metatarsal head in which radiological changes were not yet manifest. Note the wreath of dorsal and lateral excrescences, the dorsal being particularly pronounced; the normal convexity of the head is preserved.

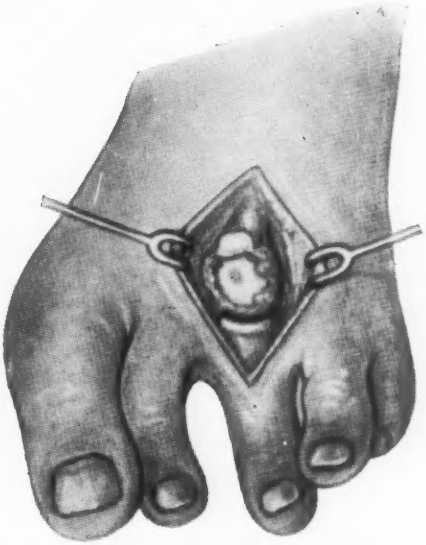


FIG. 25.—The appearances in a less early case than the preceding. The dorso-distal aspect of the metatarsal head now presents a depressed disc, which can be sprung in and out by the application and release of pressure.

The earliest appearances observed at operation are shown in *Fig.* 24, from a case in which radiological changes did not appear till later. The presence of more advanced changes in the other foot provided the opportunity for operation. The wreath of excrescences on the dorsal and lateral surfaces of the head was excised, and found to consist of bone with a covering of proliferating cartilage and fibrous tissue, probably reactionary in character. Excision of the head, which might have taught most, was considered unjustifiable.

Later the disc of bone wreathed by the peripheral outgrowths and lying on the dorso-distal aspect of the head becomes depressed, the condition usually found at operation (*Fig.* 25). The depressed disc can be sprung in and out by the application and release of pressure. The appearances in sagittal sections of the portion of head resected at operation are exemplified in *Fig.* 26. The dorso-distal

depressed disc of cartilage is seen to be much thickened, and has remnants of dead bone adherent to its deep aspect. Deep to this there are considerable vacuities, which had probably been occupied by debris, because remnants of this, with a few fragments of dead trabeculæ, are found in the margins of the reparative tissue which fills the remainder of the region deep to the depressed disc. The reparative tissue consists of young connective tissue and contains newly formed cartilage, osteoid tissue, and bone. The ingrowth appears to arise from the adjoining

FIG. 26.—Sagittal section of the portion removed from the metatarsal head in a case of osteochondritis. In the lower part normal bone is seen deep to articular cartilage of normal thickness and contour. In the upper part of this region marrow fibrosis is seen. The upper half of the section consists of thickened depressed articular cartilage with a thin broken shell of dead bone attached to its deep surface; deep to this lies young connective tissue, which contains new bone and cartilage and some necrotic tissue which it appears to be invading. The dorsal excrescence is wanting from the section. (× 5.)

FIG. 27.—Lateral radiograph of the excised portion of a metatarsal head in a case of osteochondritis. Note: below, the normal bony texture and articular contour; intermediately, the disturbed bony texture and the depression of the articular surface; above, the dorsal excrescence.

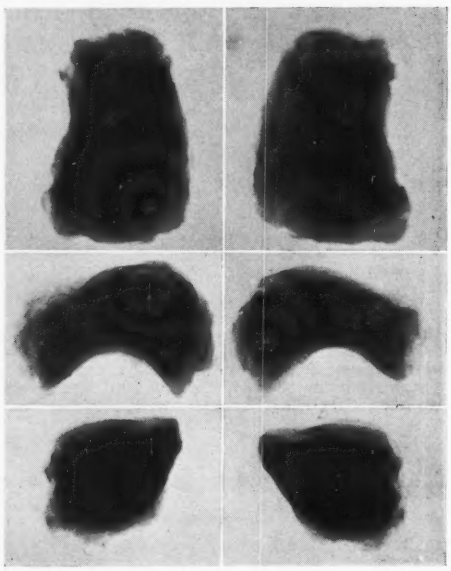


FIG. 28.—Osteochondritis of a semilunar bone. Radiographs of an excised specimen in various projections. Note the area of trabecular destruction below the upper articular surface.

marrow spaces of the normal bone composing the plantar part of the head. The general microscopical anatomy may be compared with the radiological appearances of an excised specimen (*Fig.* 27).

The depressible cartilaginous disc with an adherent bony layer tempts an analogy with osteochondritis dissecans, but this can be discounted.

b. Changes in the Semilunar Bone (Kienböck's Disease).—Apart from deformity, the most conspicuous feature of the excised osteochondritic semilunar bone is that the upper articular surface can be sprung in and out by the application and release of pressure.

Radiographs of the excised bone show areas in which the trabeculæ have disappeared (*Fig.* 28), and these areas are most pronounced beneath the middle of the upper articular surface.

The characteristic histological appearances are shown in *Fig.* 29. The middle portion of the upper articular cartilage is thickened and overlies an area of debris. This is undergoing invasion by young connective tissue showing much osteogenic

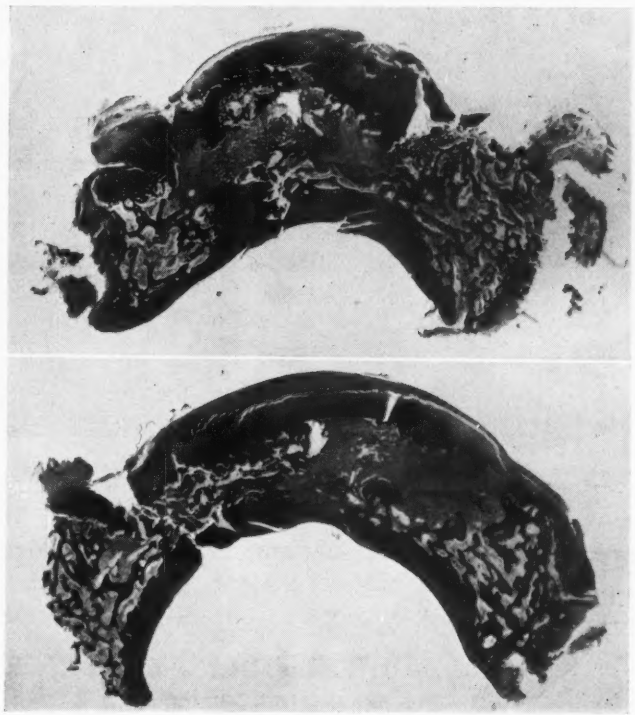


FIG. 29.—Osteochondritis of the semilunar bone. Sagittal sections of an excised specimen. Underlying the central thickened portion of the upper articular cartilage is a region of trabecular destruction which is occupied by debris containing remnants of dead trabeculæ. The debris is undergoing invasion by young connective tissue which shows osteogenic activity and contains osteoid and chondroid tissue. The invasive tissue appears to arise from marrow fibrosis in the otherwise normal bone of the anterior and posterior poles. The lower section shows a breach in the inferior articular cartilage bridged by chondroid tissue; this may have resulted from a fracture. (× 3.)

and chondrogenic activity. The bone at the anterior and posterior poles seems normal, and from its adjacent marrow spaces the invasive tissue appears to arise. *Fig.* 30 shows, under higher magnification, the debris undergoing invasion.

In addition to the appearances described, a fibrous or fibro-cartilaginous intersection is often found. Occasionally this is the only pronounced change. Of six bones removed whole, four showed histological evidence of old fracture, but whether this had preceded or followed the other changes is uncertain. In radiographs a frequently seen upper and outer pedunculated excrescence is reminiscent

of the dorsal outgrowth in osteochondritis of a metatarsal head, but loss of the excrescence during excision of the bone precludes histological examination.

The Essential Pathological Changes.—It would seem that the essential pathological changes in coxa plana and in the kindred conditions of the metatarsal bones and semilunar bone are the following :—

1. Necrosis of a special kind with lysis of trabeculæ.

2. Invasion by young connective tissue, resulting in (*a*) phagocytosis, (*b*) regeneration.

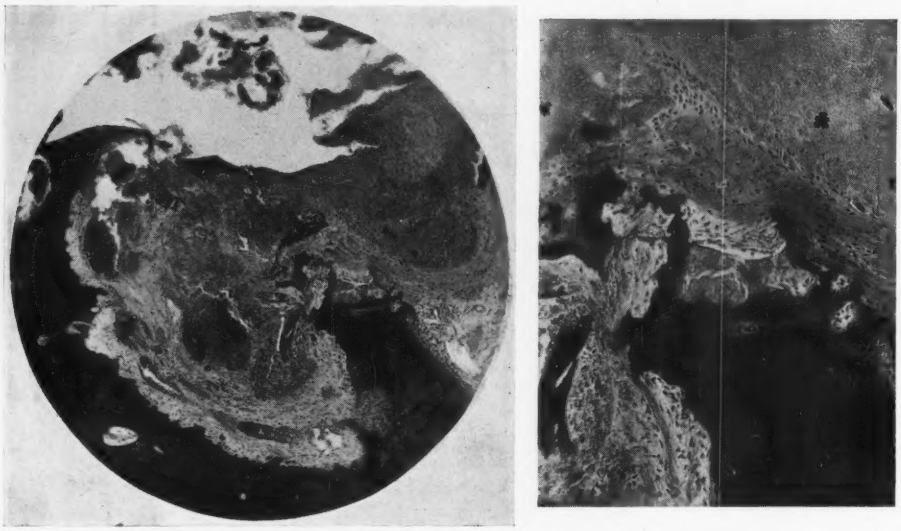


FIG. 30.—Osteochondritis of the semilunar bone. Invasion of debris by young connective tissue. (× 36 and × 90.)

The chief destruction tends to be subchondrally situated, and the term ' subchondral necrosis ' is probably the best yet devised for the change. ' Subchondral lysis ' would perhaps be better.

RADIOLOGICAL CHANGES

Consideration of some Radiological Changes in the Light of the known Pathological Changes.—

1. *The Increase in the Joint Interval above the Epiphysial Nucleus.*—The increase may be ascribed to thickening of the femoral articular cartilage. This has been attributed to normal growth of the cartilage in the absence of coincident invasion of its deep surface by bone, this having died. Such explanation is incorrect, because the writer has found the increased joint interval in early cases before the affected bony nucleus has become appreciably smaller than its fellow. The cartilaginous thickening may be analogous to that found over the necrotic region in cases of osteochondritis of the semilunar bone (*Fig.* 26) or a metatarsal bone (*Fig.* 29).

2. *Flattening of the Epiphysial Nucleus.*—Though this doubtless depends largely on plasticity of the nucleus in later cases, the writer has found in earlier cases substantial flattening without increase in width of the nucleus, so that the early deformity probably depends upon the destruction within the nucleus.

3. *Rarefaction in the Epiphysial Nucleus.*—The early foci of rarefaction presumably result from the destruction of trabeculæ and their replacement by necrotic debris, which will be transradiant pending its calcification. Later, the ingrowth of young phagocytic and reparative tissue must be a factor, especially as its products are at first largely osteoid tissue and cartilage—both, like the parent tissue, transradiant.

4. *Increased Density in the Epiphysial Nucleus.*—Granted that the increased density is not merely relative, several factors probably play a part. Among them must be reckoned calcification of debris, for which we have pathological evidence.

The essential Radiological Criterion of Osteochondritis.—If it be allowed that lysis of trabeculæ is characteristic of osteochondritis of the hip, then conditions elsewhere should not be accepted as akin to it unless they show, at the least, radiological evidence of obliteration of trabeculæ at some stage. Were this criterion applied, many alleged examples of osteochondritis in various situations would be discounted.

COMPARISON AND CONTRAST OF THE PATHOLOGICAL AND RADIOLOGICAL CHANGES IN OSTEOCHONDRITIS JUVENILIS WITH THE KNOWN CHANGES OF ORDINARY ASEPTIC NECROSIS

The predominant *radiological* change in ordinary aseptic necrosis is an increase in density, whether relative or real, of the trabeculæ, the texture of which is perfectly preserved (*Figs.* 31, 32), although it may become confused in the

FIG. 31.—Radiograph in a case of aseptic necrosis of the proximal fragment of a fractured carpal scaphoid bone. Note the perfect preservation of the texture of the dead trabeculæ.

FIG. 32.—Radiograph of the excised femoral head from a case of aseptic necrosis following transcervical fracture. The texture of the trabeculæ is perfectly preserved except in a small area at the left-hand margin of the specimen, where subsequent microscopical examination showed beginning creeping substitution to be most advanced.

occasional case complicated by secondary collapse. Only later may the trabecular structure be lost in places, by reason of the advancing areas of rarefaction which

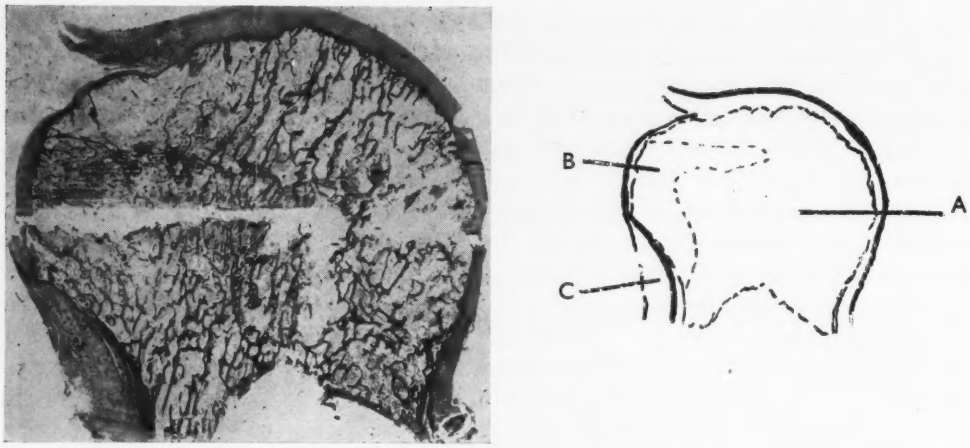


FIG. 33.—Section from the specimen whose radiograph is shown in the preceding figure. The trabeculæ and bone-marrow are dead, but in the left-hand part the marrow spaces are filled with invasive young connective tissue which is laying down new bone on the dead trabeculæ (*see Fig.* 34). A, Dead bone and dead marrow; B, Zone of invasion by young connective tissue which is laying down new bone on the dead trabeculæ; C, Highly vascular fibrous tissue. (× 1·45.)

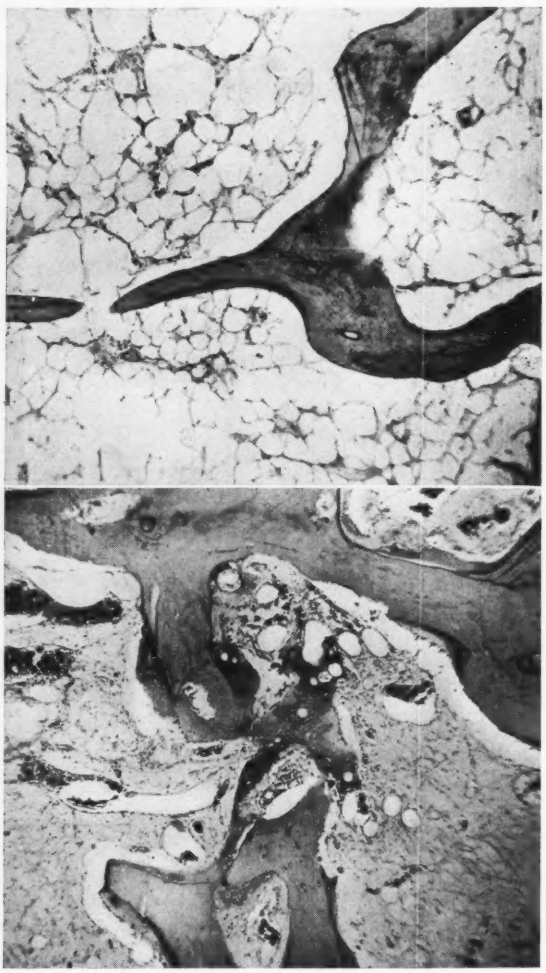


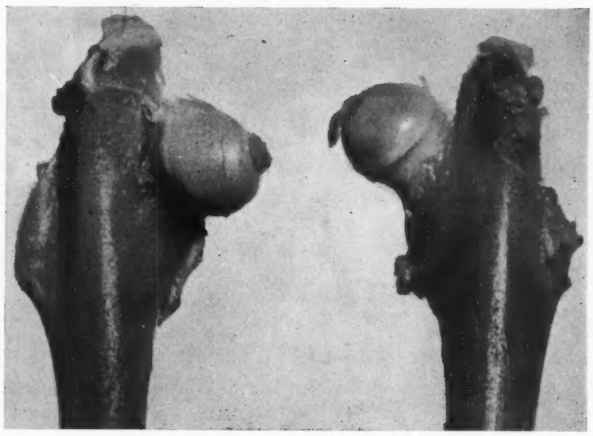
FIG. 34.—Portions of the preceding section under higher magnification. The upper photomicrograph (A) is from the right-hand part of the section shown in the preceding figure. Only dead bone and dead marrow are seen. The lower photomicrograph (B) is from the left-hand part of the section shown in the preceding figure. The dead marrow is replaced by an ingrowth of young highly vascular connective tissue, which is laying down new bone; this is seen in greatest quantity in the centre of the photograph. (× 40.)

mark the inroad of osteoclastic and reparative tissue. In osteochondritis, on the other hand, bony texture becomes blotted out at a comparatively early stage. The contrast is well seen by comparing the largely obliterated texture of the osteochondritic semilunar bone with the perfectly preserved texture of the necrotic half scaphoid bone shown in *Fig.* 31.

The most striking *histological* change in ordinary aseptic necrosis of bone is death of the marrow. Although the bone cells also die, the trabeculæ are perfectly preserved until they can be systematically replaced by an ingrowth of young connective tissue, the process of ' creeping substitution '. These changes are shown in *Figs.* 33, 34, which are prepared from the same specimen as *Fig.* 32. In osteochondritis there occurs gross destruction of trabeculæ in addition to their mere death, and this destruction precedes the invasion by young phagocytic and reparative tissue.

POSSIBLE CAUSES OF THE DIFFERENCE BETWEEN OSTEOCHONDRITIS JUVENILIS AND ORDINARY ASEPTIC NECROSIS

The immediate cause of the difference between the two processes may well depend upon the special anatomical circumstances common to such situations as the epiphysis in a child and the bony centre of a carpal bone in an adult. The special circumstances are that a nucleus of bone, which is dependent on a blood-supply, is almost completely enclosed in an unyielding envelope of cartilage which



A B

FIG. 35.—Flattening and expansion of the femoral head, and shortening and thickening of the femoral neck, following division of the round ligament in a young rabbit. A, Experimental side; B, Normal side.

is largely independent of the circulation. There seem to be two ways in which this peculiar environment may be a factor in the difference between the changes of osteochondritis juvenilis and those of ordinary aseptic necrosis.

It may be that both conditions result from arterial anæmia, but that, in the special anatomical circumstances mentioned, the effects of this are atypical.

Alternatively it may be that the primary cause of the necrosis is different. Possibly in osteochondritis juvenilis we are concerned with venous obstruction as distinct from arterial obstruction, or with hæmorrhage within the bony nucleus lying in its restraining cartilaginous envelope.

Experimental Work bearing on these Points.—Numerous attempts at the experimental production of coxa plana in various animals have resulted in bony changes, but have failed to reproduce the radiological or histological characteristics

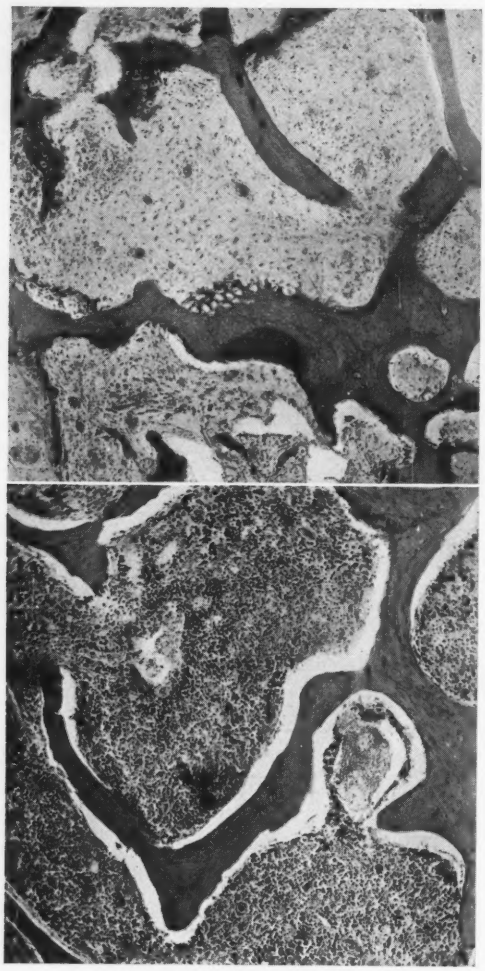


FIG. 36.—Photomicrographs to show the changes produced in the epiphysial nucleus of the femoral head of the young rabbit by division of the ligamentum teres. The upper figure (A) shows the changes on the experimental side. Note that the marrow spaces between the dead trabeculæ are filled with young connective tissue which is laying down new bone and cartilage. The changes are those associated with ordinary aseptic necrosis and its repair. No foci of lysis of trabeculæ are found. The lower figure (B) shows the normal bone of the control side. (× 64.)

of coxa plana. To test the effect of total vascular occlusion, the writer, repeating one of these experiments in young rabbits, divided the ligamentum teres, which provides much of the blood-supply of the epiphysis of the femoral head in the rabbit younger than five weeks. On killing the animals at various periods after operation, he found, like other workers, flattening of the femoral head (*Fig.* 35).

Nevertheless, at whatever interval, after operation, examination was carried out, there were found radiologically no changes in texture, and histologically no areas of replacement of trabeculæ with debris, such as are the chief features of osteochondritis. The histological changes (*Fig.* 36) were those of ordinary aseptic necrosis and its repair. The flattening of the femoral head seems to be the result of post-operative subluxation (*Fig.* 37).

A B

FIG. 37.—Subluxation of the hip following arthrotomy with division of the ligamentum teres in a young rabbit. A, Experimental side; B, Control side. It is suggested that subluxation is responsible for the changes seen in *Fig.* 35.

With the reserve necessary in applying the results of animal experiments to man it is concluded that the anatomical peculiarities of an epiphysial nucleus do not seriously influence the effects of arterial anæmia, which are merely those of ordinary aseptic necrosis as seen elsewhere.

It would be desirable to find experimentally whether the special effects found in osteochondritis would result from other forms of vascular disturbance, but methods for producing either venous occlusion, without arterial occlusion, or hæmatoma formation in the epiphysial nucleus, without breach of the articular cartilage, were impracticable in the experimental animal.

A SPECULATION AS TO CAUSATION

Predisposing Condition.—The unusual familial and not infrequent bilateral cases might be explained by some anatomical abnormality or subnormality, but its nature is obscure. A vagary of blood-supply seems possible; congenital subluxation can be excluded.

Precipitating Cause.—The experimental work described suggests that arterial anæmia does not produce the condition. Infection, as a cause, is highly improbable

on many counts. It has been suggested here that the changes might perhaps result from venous obstruction without arterial obstruction or from hæmorrhage within the bony nucleus. How, in the patient, might these happen?

a. Venous Obstruction.—In cases of coxa plana preceded by transient arthritis affecting the hip, with or without other joints, the effusion may exert pressure on the veins draining the epiphysis so that they become obliterated. Comparable changes may account for the cases of osteochondritis juvenilis associated with tuberculous arthritis. The effusion following reduction of a dislocation might have the same effect, or the veins might be more directly injured.

b. Hæmatoma Formation within the Nucleus.—This might well result from reduction of a dislocation or from other stress, especially if a subchondral fracture is envisaged. Reference has already been made to the histological evidence of fracture sometimes present in the osteochondritic semilunar bone, but with doubt as to whether the fracture preceded or followed the other changes.

These considerations are of speculative interest only and are much less important than ascertained fact.

KINSHIP OF COXA PLANA

The term osteochondritis juvenilis, having been applied originally to coxa plana, should be used for conditions elsewhere in the body only if there is reasonably good evidence of their kinship with coxa plana. Superficial resemblances, usually clinical and radiological, have sufficed for the use of the term for many epiphysial dystrophies and other conditions. Accordingly we have formulated certain minimal pathological and dependent radiological criteria which should be satisfied before kinship with coxa plana is presumed. Similarity of histological appearances does not prove aetiological identity, but is valuable contributory evidence of pathological relationship. A study of the alleged examples of osteochondritis in various parts of the body with special reference to the criteria enunciated has led the writer to the following conclusions and classification :—

1. Kinship with Coxa Plana—conditions giving both radiological and histological evidence of lysis—osteochondritis of the tarsal scaphoid bone (Köhler's disease), of a metatarsal head (Freiberg's disease), and of the semilunar bone (Kienböck's disease).

2. Probable Kinship with Coxa Plana—conditions giving only radiological evidence of lysis, histological evidence being unavailable—osteochondritis of the primary centre of a vertebral body (Calvé's disease) and osteochondritis juvenilis of the capitellum (Panner's disease, to be distinguished from the more frequent condition of osteochondritis dissecans).

3. No Kinship with Coxa Plana—no satisfactory evidence, either radiological or histological, of lysis—other alleged examples of osteochondritis juvenilis, including ' generalized osteochondritis '.

TREATMENT

Treatment in the active stage only will be discussed.

No method designed to modify the pathological process itself and so hasten repair seems to have succeeded. The most that offers any prospect of success is maximum preservation of the contour of the femoral head, and on the success of this the functional prognosis chiefly turns. This is best in the young, youth being

probably the most important prognostic factor. This is readily explained by the fact that the epiphysial nucleus becomes partly pulped, so that the integrity of the head depends mainly upon its cartilaginous dome. The younger the patient, the thicker this is and the smaller its span; consequently it is strongest at a time when the deforming forces of body-weight and muscle pull have not yet become substantial.

The nearest approach to the logical ideal of eliminating both these deforming forces is provided by traction continued without important intermission till healing has occurred, a matter often of years rather than of months. The method implies recumbency and is most readily contemplated for the younger children, but such tend to do fairly well in any event. Only a substantial advantage demonstrated in practice could warrant a general use of the method. Eyre-Brook obtained better results in a group of cases so treated than in a group treated otherwise, but the patients in the former alone were inmates of an institution, so that the results may have depended less on the method than on the conscientiousness with which it was applied.

The objections to traction if prolonged do not obtain with the same procedure as a temporary measure to counter joint irritation, and consequent muscle spasm, sometimes present at the outset.

The most generally suitable treatment is probably still the use of a weight-relieving caliper. The chief difficulty is to maintain its weight-relieving qualities, unless it be of patten-ended form, which is scarcely suitable for the older patients, who are those in most need of effective relief from weight-bearing. The writer's very limited experience of Trumble's splint has discouraged its trial for coxa plana, but others might find it satisfactory.

Operative treatment is not warranted during the active stage, unless the condition starts as late as about the sixteenth year; in this uncommon event, the response to conservative treatment is often bad, so that it may be better to perform an operation, such as Whitman's, during the active stage rather than expend much time on other treatment.

PRINCIPAL CONCLUSIONS

1. Coxa plana proves histologically to be a condition of necrosis of bone followed by repair.

2. The necrosis differs from ordinary aseptic necrosis in showing lysis of trabeculæ.

3. Infection cannot be excluded as a cause of the lysis, but is highly improbable.

4. The results of animal experiments suggest that the lysis is not due to arterial anæmia occurring in the special anatomical circumstances of the presence of bone in an envelope of cartilage.

5. A possible cause is some form of vascular disturbance other than arterial anæmia—either venous obstruction or hæmatoma; the anatomical circumstances are such that either of these events might have profound results.

6. Recognition of the special pathological changes assists the accurate definition of ' osteochondritis juvenilis ' occurring at sites other than the hip and the rejection of alleged examples which lack the essential criteria which might properly justify an analogy with coxa plana.

7. Recognition of histological criteria suggests that the following are akin to coxa plana: osteochondritis of the tarsal scaphoid bone (Köhler's disease), of the

metatarsal head (Freiberg's disease or Köhler's second disease) and of the semilunar bone (Kienböck's disease).

8. On grounds of critical radiology, without histological information, it is probable that osteochondritis of the vertebral body in infants (Calvé's disease) and osteochondritis juvenilis of the capitellum (Panner's disease) are further examples.

9. Other alleged examples of osteochondritis juvenilis, with one or two possible exceptions, probably belong to unallied conditions and are not analogous to coxa plana.

10. In assessing these conclusions only the weight it deserves should be accorded to evidence based on identity of histological appearances or the results of animal experiments.

With a brief summary it is impossible to do justice in a list of references, and therefore none is given; King's Jacksonian Prize Essay has been a lavish source. Similarly it is impossible to name all those who have given generous assistance, but that received from Mr. R. C. Elmslie, Sir Arthur Keith, and Mr. S. L. Higgs needs emphasis. The work was undertaken at the Royal College of Surgeons and, through the kindness of Professor J. Paterson Ross, in the Dunn Laboratory of St. Bartholomew's Hospital. The larger bone sections were prepared by Mr. Chadwynd of Miss Hawksley's laboratory at the Royal Cancer Hospital. It is hoped that later the publication of a small monograph on 'osteochondritis juvenilis' may make possible amplification of evidence and acknowledgements and the inclusion of references. Publication is by kind permission of the President and Council of the British Orthopædic Association.

EXOMPHALOS*

RADICAL CURE IN AN INFANT, TWENTY MINUTES OLD

By LAMBERT ROGERS, Cardiff
PROFESSOR OF SURGERY, UNIVERSITY OF WALES

During the forenoon of Jan. 5, 1935, a midwife bearing in her arms a newly born child was announced at the entrance to the theatre where I was carrying out a morning's list of operations. She had been sent up from the Casualty Department, as the baby, born within the past half hour, quite close to the Royal Infirmary, was found to have complete exomphalos. The child was full term and inspection showed a well-developed girl baby whose abdominal viscera were lying on the abdominal wall covered only by a transparent, Whartonian jelly-like membrane. The enormous size of the liver, which lay entirely outside the abdomen along with the whole of the small and the greater part of the large intestine, was a striking feature.

Fig. 38.—Condition at 4 years of age. Child born with complete exomphalos and operated upon when twenty minutes old.

Operation.—The child was taken into the theatre at once, placed on the table, and without anæsthesia an attempt made to replace the viscera prior to repairing the gap in the abdominal wall. The liver was first put back, but it was then found that it was not possible to replace the intestines so these had first to be introduced and the liver afterwards. In order to carry out this replacement the gelatinous membrane had to be opened and a number of fine vascular cœlomic adhesions divided, while the gap in the abdominal wall was slightly extended upwards by an incision which facilitated returning the liver. The edges of the large gap in the abdominal wall were approximated with silkworm gut through-and-through sutures. Although considerable handling of the viscera was necessary for their replacement, the child was not perceptibly disturbed and made an uninterrupted recovery. *Fig.* 38 shows the condition four years afterwards. There is some bulging of the ventral scar tissue between the recti and she has double inguinal herniæ, but is a bright healthy

* From the Surgical Unit, The Royal Infirmary, Cardiff.

little girl apparently normal in every way. From New Zealand, where at 6 years of age she is now living with her parents, the latest news is that she is very well and has just started to attend school.

The latest edition of a standard textbook of surgery makes the statement that " exomphalos is merely of pathological interest."

Comment.—The object of this report is to indicate that, although such a lesion may appear quite hopeless, it is well worth performing a radical cure; and, secondly, the loosely anchored and irregularly placed viscera have not so far caused symptoms or menaced the child's existence in any way. The alimentary canal is apparently functioning normally. The inguinal herniæ call for treatment later. Lastly, a severe manhandling type of operation was easily weathered by a newborn child who exhibited no signs of shock, respiratory distress, or other complication. No doubt at this early age the child is adapted to the trauma of birth and well able to accommodate itself to what may be described as merely an extension of this trauma in the form of a major abdominal operation. Such an operation is in the nature of an artificial completion of a physiological process, incomplete because of the persistence of the extra-embryonic cœlom. In other words, we may say that surgical obliteration of the extra-embryonic cœlom in a newly born infant is merely a greatly accelerated physiological event brought about artificially by surgery, to which the developing child is already adapted and to which therefore it presents little reaction.

THORACICO-ABDOMINAL GASTRECTOMY FOR CARCINOMA OF THORACIC STOMACH

By RONALD W. RAVEN

SURGEON, E.M.S. (SECTION VII); ASSISTANT SURGEON, ROYAL CANCER HOSPITAL (FREE), AND GORDON HOSPITAL

THE presence of either a portion or the whole of the stomach within the confines of the thorax is an uncommon phenomenon apart from an associated diaphragmatic hernia. The relationship between the developing stomach and heart seen during the fourth week of embryonic life is soon estranged by the formation of the diaphragm when the stomach enters within the confines of the abdomen. It is now twenty years since Percival Bailey enriched our knowledge of congenital anomalies by describing the viscera of a certain Ephraim Trimble, who died aged 77 in the Lake Forest Sanatorium of Cork County. This patient had suffered no gastro-intestinal or cardiac disturbances during life, but anatomical dissection of his body after death revealed his stomach in the posterior mediastinum of the chest. Since this discovery the condition of thoracic stomach with congenital shortening of the œsophagus has attracted the attention of clinicians and radiologists, and contributions have been made to the literature by Le Wald, J. B. Hume, R. E. Roberts, H. Morris, T. P. Dunhill, J. P. Ross, L. Findlay, Brown Kelly, and others concerning the symptomatology and diagnosis.

It is a reasonable supposition that the same diseases will occur in an intra-thoracic stomach as in an intra-abdominal stomach, and therefore lesions such as benign and malignant ulcers and primary carcinoma should be encountered. A study of the literature concerning thoracic stomach has failed to reveal a description of a case of carcinoma occurring in a thoracic stomach and this pathological lesion must therefore be a rarity. A patient with this condition recently came under the care of the writer in the Royal Cancer Hospital (Free), and a study was made of the diagnosis and treatment of the disease. The surgical excision of the lesion was contemplated and careful consideration was given to the surgical principles involved in such an operation, and, in addition, the technique was worked out on the cadaver. The object of this paper is to present the clinical case record of the symptomatology, investigation, and diagnosis of carcinoma of the thoracic stomach and to describe in detail the operation devised for the extirpation of the disease. It is hoped that the recital of this experience will be of value to surgeons who may encounter similar cases in the future and for those who may contemplate surgical intervention on the œsophago-gastric region for other conditions.

CASE REPORT

A male, aged 58, was admitted to hospital complaining of vomiting blood. For several years he had experienced indigestion, and six weeks before admission he vomited half a pint of bright red blood. There was no pain or dysphagia and no recent loss of weight.

ON EXAMINATION.—He was in good general condition. The lungs showed signs of chronic bronchitis and emphysema; there was no abnormality of the heart and the blood-pressure was normal. The abdomen and rectum appeared normal. An X-ray examination after barium showed that the œsophagus was short, with a portion of the stomach present in the chest, and an organic stricture was seen at the lower end of the œsophagus. Above

the stricture there was slight dilatation, with reversed peristalsis. On œsophagoscopy a carcinoma was seen at the lower end of the œsophagus 37 cm. from the incisor teeth and a biopsy was performed. Microscopical examination of this tissue showed fibrous tissue heavily infiltrated by poorly differentiated adenocarcinoma of low columnar type, the histological features being more suggestive of a gastric carcinoma than of a carcinoma which has originated in heterotopic gastric glands in the œsophageal mucosa. The blood-picture was normal and the Wassermann reaction negative.

TREATMENT.—The following operations were performed :—

May 27.—Anastomotic jejunostomy (after Mayo-Robson) under local infiltration anæsthesia with 1 per cent novocain solution.

June 13.—Induction of left artificial pneumothorax.

June 21.—Thoracotomy and thoracico-abdominal partial gastrectomy with œsophago-gastrostomy anastomosis under high spinal anæsthesia with 1–1500 percaine solution and inhalation anæsthesia with vinesthene, nitrous oxide, and oxygen. A continuous blood transfusion was given during and after the operation. On returning to bed his condition was very satisfactory with a pulse-rate of 90 and a systolic pressure of 120. He was placed in an oxygen tent and his condition remained good, there being no restlessness, sweating, cough, or discharge from the tube in the pleural cavity. Twenty-four hours later the patient developed the signs of failure of the right heart and he died on June 23.

POST-MORTEM EXAMINATION.—Autopsy showed marked distension of the right auricle of the heart, with wide separation of the muscle bundles ; the right ventricle was dilated with a thin wall and microscopical examination showed considerable fragmentation of the muscle-fibres resulting from rapid dilatation. The suture line of the œsophago-gastrostomy anastomosis and the suture line closing the stomach at the site of resection were intact and did not permit of oozing from the interior of either organ. The cause of death was cardiac failure, with dilatation of the right heart. There was a degree of myocardial degeneration and the heart was unable to compensate for the additional burden imposed upon it. Reviewing the case, it is felt that the blood transfusion given during and after the operation, together with the blood volume of one collapsed lung, threw an added burden on the circulatory mechanism.

THE SPECIMEN.—The specimen consists of the lower end of the œsophagus, 1 in. long, opening into a saccular portion of the stomach 3 in. in diameter. In the stomach there is a carcinomatous ulcer of 1 in. diameter situated below and to the left of the cardiac orifice. There are no enlarged lymph-nodes. Microscopical examination shows a fairly large well-differentiated columnar-cell adenocarcinoma of gastric origin, infiltrating almost the whole thickness of the wall.

THE OPERATION OF THORACICO-ABDOMINAL GASTRECTOMY

Indications.—

1. Benign chronic peptic ulcer in a thoracic stomach.
2. Malignant peptic ulcer in a thoracic stomach.
3. Carcinoma of thoracic stomach.
4. Carcinoma of lower segment of œsophagus.
5. Carcinoma of stomach involving the cardiac orifice and lower segment of œsophagus.

Preliminary Treatment.—

1. Jejunostomy (Mayo-Robson technique).
2. Induction of left artificial pneumothorax.

Technique of Operation.—

Position of Patient on the Operation Table.—The patient lies on the right side with a small pillow beneath the right lower ribs. The knees are drawn up and the left upper extremity is held outwards and upwards.

Incision in the Parietes.—A curved incision is made over the left 8th rib commencing at the costal cartilage and extending upwards and backwards so as

to expose the whole rib. The periosteum covering the 8th rib is elevated and 24 cm. of the rib removed. The periosteum covering the posterior extremities of the 7th and 9th ribs is elevated and the posterior extremities of these ribs are divided with a costotome. The pleural cavity is then opened and a rib-spreading retractor inserted.

Identification of the Œsophagus.—The collapsed left lung is retracted forward. The greatest obstacle in visualizing the œsophagus is the pericardium, and this structure should be retracted forward by the hand of the assistant. The œsophagus is then seen lying between the descending thoracic aorta behind and the pericardium in front. Other structures visualized are the diaphragm below, the left phrenic

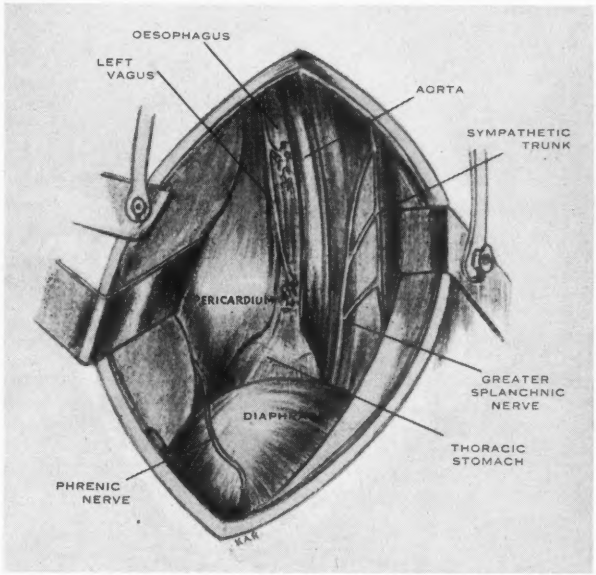


FIG. 39.—Relations of thoracic stomach exposed after thoracotomy with partia excision of the left 8th rib.

nerve with accompanying blood-vessels passing downwards on the left side of the pericardium, and the left vagal plexus on the anterior aspect of the œsophagus.

Identification of the Thoracic Stomach (*Fig.* 39).—The thoracic stomach lies in the posterior mediastinum behind the pericardium and between the pleural cavities. It is completely surrounded by a serous sac which is continuous with the peritoneum through the opening in the diaphragm.

Injection of the Œsophageal Vagal Plexus and Crushing of the Left Phrenic Nerve.—In order to intercept nociceptive impulses during subsequent manipulations in the posterior mediastinum, the œsophageal vagal plexus is injected with a solution of 2 per cent novocain. The left diaphragm is paralysed in order to facilitate further operative procedures by crushing the left phrenic nerve with a hæmostat.

Mobilization of the Lower End of the Œsophagus, and Thoracic and Abdominal Portions of Stomach (*Fig.* 40).—The mediastinal pleura overlying the œsophagus is divided, together with the serous covering of the thoracic stomach. If possible this serous covering should be preserved to reinforce the œsophago-gastrostomy

anastomosis. The orifice in the diaphragm transmitting the thoracic stomach is enlarged by making a radial incision anterolaterally to the left. Great care must be taken when the lower 3 in. of the œsophagus is mobilized to avoid injury of the small artery from the thoracic aorta to the lower third of the œsophagus and to avoid bruising of the mediastinal tissues.

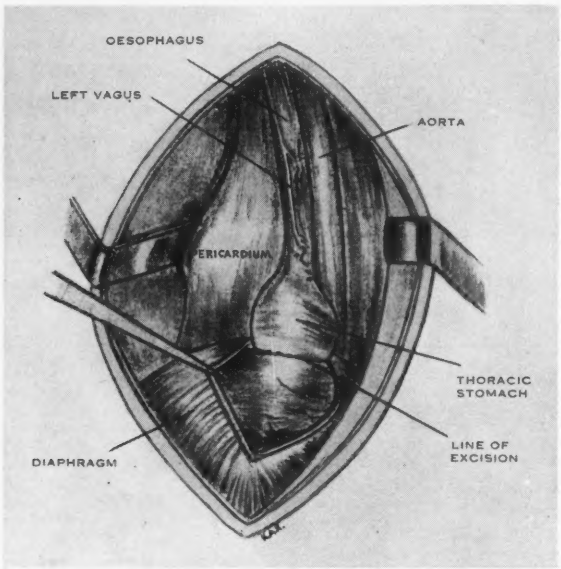


FIG. 40.—The diaphragm has been incised, exposing the abdominal stomach, and the line of excision of the thoracic stomach is seen.

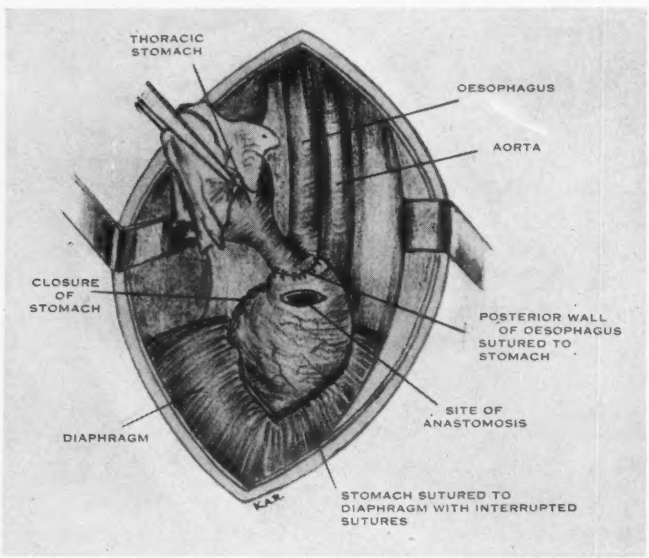
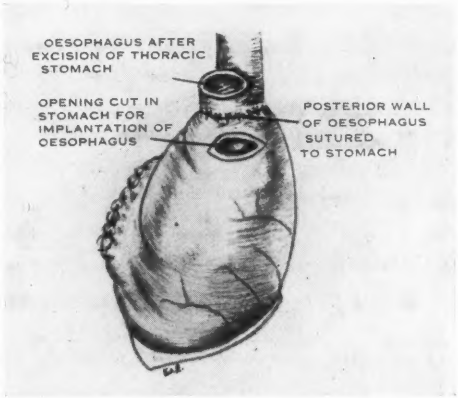


FIG. 41.—The thoracic stomach has been divided from the abdominal stomach and the opening in the latter structure has been closed. The posterior wall of the œsophagus has been sutured to the abdominal stomach and the new opening for the anastomosis is shown.

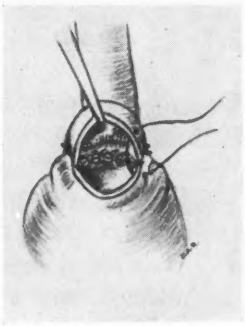
The thoracic and abdominal portions of the stomach are next mobilized. The tissues along the upper third of the lesser curvature are divided and it will be necessary to ligate the œsophageal branches of the inferior diaphragmatic and the left gastric arteries, and branches to the stomach from the left gastric artery; it may be required to ligate the left gastric artery itself.

Excision of the Thoracic Stomach and Lower Extremity of the Œsophagus (*Fig.* 41).—Intestinal clamps are applied transversely across the junction of the thoracic and abdominal portions of the stomach and the stomach is divided. The distal end of the stomach is closed by two layers of Czerny-Lambert sutures of No. 1 chromic catgut. The abdominal portion of the stomach is now delivered through the diaphragm into the thorax and the œsophago-gastrostomy anastomosis is performed.

Suture Technique of Œsophago-gastrostomy (*Fig.* 42).—The thoracic stomach with the lower end of the œsophagus is rotated upwards and a suitable site in the abdominal stomach for the anastomosis is selected. The abdominal stomach is sutured to the posterior wall of the œsophagus with interrupted sutures of fine linen thread which pass through the muscle layer of the œsophagus and


OESOPHAGUS AFTER EXCISION OF THORACIC STOMACH
OPENING CUT IN STOMACH FOR IMPLANTATION OF OESOPHAGUS
POSTERIOR WALL OF OESOPHAGUS SUTURED TO STOMACH

A



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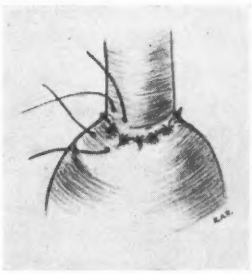

C

FIG. 42.—The technique of œsophago-gastric anastomosis. A, Posterior wall of œsophagus sutured to stomach and new opening made in stomach; B, Anastomosis of œsophagus and stomach—the posterior layer of interrupted sutures inserted and the anterior layer begun; C, Anastomosis between œsophagus and stomach completed with anterior layer of interrupted sutures.

seromuscular layers of the stomach. The thoracic stomach is now removed by transverse section of the lower part of the œsophagus without the application of clamps and the mediastinum should be packed off lightly with gauze to prevent the possibility of soiling. A transverse incision is made in the abdominal stomach corresponding to the diameter of the œsophagus. The posterior walls of the œsophagus and stomach are sutured together with interrupted sutures of fine linen thread through all the coats. Care must be taken to approximate the mucous membrane of the stomach with that of the œsophagus. The anterior walls of the stomach and œsophagus are approximated in a similar manner and the anastomosis

is completed by an anterior layer of interrupted sutures of linen thread approximating the seromuscular layers of the stomach with the muscle layer of the œsophagus. If possible the serous covering left after removing the thoracic stomach should be applied to the anastomosis.

Closure of the Diaphragm.—The orifice in the diaphragm is sutured to the stomach 2 in. below the anastomosis by interrupted sutures of catgut. Care must be taken to ensure that there is no tension on the œsophago-gastrostomy anastomosis.

Closure of the Thoracic Cavity with Drainage.—Closed drainage of the left pleural cavity is instituted by the insertion of a rubber catheter through a stab incision in the 9th intercostal space. The 7th and 9th ribs are approximated by tension sutures of catgut. The pleura and intercostal muscles are sutured with continuous sutures of catgut and the subcutaneous muscles and fascia are approximated with a continuous suture of catgut. The skin is closed with a continuous suture of silk. Continuous closed suction drainage of the left pleural cavity is carried out.

The temporary jejunostomy should be allowed to close six weeks later.

A Consideration of the Surgical Principles Involved.—

1. *The Nutrition of the Œsophagus.*—One of the most important considerations in the surgery of the œsophagus is the blood-supply. Anatomical dissection of the arterial blood-supply to the œsophagus shows considerable segmental variation. There is a poor blood-supply to the cervical segment, and the segment immediately above the diaphragm. The blood-supply to the lower portion of the supradiaphragmatic part of the œsophagus is furnished by a small branch of the thoracic aorta which divides into ascending and descending branches, together with branches from the inferior diaphragmatic and left gastric arteries. The entire upper half and the upper two-thirds of the lower half of the thoracic œsophagus and the abdominal segment receive an adequate supply of blood. For operative procedures involving the immediate supradiaphragmatic œsophagus care must be taken to ensure safety for the meagre blood-supply.

2. *The Influence of the Vagus Nerve upon Respiratory Function.*—Stimulation of the vagus nerves causes irregularity, decreased rate, and deepening of the respiratory movements. Inspiratory spasm may also be seen. Injections of the vagal plexus will remove the effects of noxious stimuli.

3. *The Resistance of the Pleura to Infection.*—The resistance of the pleura to infection is poor, especially if its integrity is disturbed. Experiments carried out by Ohsawa showed that the ratio of the frequency of infection between free thoracotomy without expiration of air, thoracotomy under differential pressure with expiration of air, and free thoracotomy with expiration of air was 100 : 83 : 73.

4. *Control of the Diaphragmatic Movements.*—It has been shown experimentally that the active movements of the diaphragm will cease for one week if the phrenic nerve is crushed, and for one to two hours if impulses are blocked by injecting the nerve with cocaine.

5. *Technique of Suture in Œsophageal Anastomosis.*—There are three important factors which tend to militate against successful anastomosis where the œsophagus is concerned: (*a*) The nutrition of the œsophagus is easily impaired by interfering with the blood-supply; (*b*) There is no serous coat to the œsophagus; (*c*) Tension is not tolerated well at the line of anastomosis. Care must be taken to conserve the arterial supply to the lower end of the œsophagus in the operation which has

been described. In order to avoid tension the region of the stomach near the greater curvature is chosen for the anastomosis. In order to maintain an adequate blood-supply to the anastomotic line it is advisable to employ interrupted sutures rather than a continuous suture. In the absence of serosa a portion of the omentum should be grafted on the anastomosis.

A Consideration of the Surgical Technique of the Operation.—

1. *The Surgical Exposure.*—The surgical approaches to the different segments of the œsophagus have been standardized and described by O'Shaughnessy and Raven. Working on the cadaver the writer has reviewed the surgical approaches to the lower third of the intrathoracic œsophagus. The view expressed by O'Shaughnessy and Raven in 1934 is confirmed that the best exposure of this segment of the œsophagus is by the left transpleural approach, removing the 8th rib. By this method the œsophagus is exposed from the arch of the aorta to the diaphragm lying at a depth of 9·5 cm. from the surface of the chest wall. These factors facilitate the surgical manœuvres entailed in the operation.

2. *Intrathoracic Manipulation.*—In order to prevent bruising of the mediastinal tissues, with the risk of subsequent suppuration, extreme gentleness must be employed in handling the tissues. Care must be taken to obtain perfect hæmostasis and to avoid soiling of the tissues. It is advisable to use large gauze pads soaked in an aqueous solution of flavine to shut off the thoracic viscera from the field of operation.

3. *The Anastomosis.*—Division of the œsophageal wall should be effected without the application of clamps owing to the danger of crushing the wall and subsequent necrosis. It is felt that non-absorbable suture material is preferable to catgut for the anastomosis, and interrupted sutures should be employed rather than a continuous suture. The anastomosis should be performed in two layers.

4. *Drainage of the Chest.*—Closed syphon drainage should be instituted and every attempt made to bring about re-expansion of the collapsed lung as soon as possible.

SUMMARY

The clinical case record of the symptomatology, investigation, diagnosis, and treatment of carcinoma of a thoracic stomach is presented. The operation of thoracico-abdominal gastrectomy is described, together with the indications for the operation. The surgical principles involved in the performance of the operation are discussed and attention is drawn to matters of surgical technique.

I wish to thank my colleague, Mr. Percival P. Cole, for kindly allowing me to undertake the treatment of this patient; and my house-surgeon, Miss Kathleen M. Robinson, for the care in the pre- and post-operative treatment.

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THE EARLIEST ENGLISH EXAMPLE OF BILATERAL CERVICAL RIB

By A. J. E. CAVE, London

Prior to the Anatomy Act of 1832 the anatomist's legitimate source of material was, under certain operative Tudor enactments, the gallows—an association of executive justice with scientific inquiry which sustained and intensified the ever lively popular prejudice against anatomical study, dissection following execution being regarded as insult added to injury. Nevertheless, the ancient order served to preserve in our museums skeletal material of known age, sex, and date invaluable to the physical anthropologist. Thus it brought to the Royal College of Surgeons' Museum the skeleton of the notorious thief, Jonathan Wild (d. 1725); to the Anatomical Museum of Edinburgh University, that of the infamous William Burke (d. 1829); and to the Anatomical Museum of Leeds University that of the Yorkshire 'witch', Mary Bateman (d. 1809). Bateman's skeleton is triply interesting, by reason, firstly, of its origin; secondly, of its association with William Hey; and thirdly, of an intrinsic peculiarity rendering it unique in this gallery of malefactors, the bilateral manifestation of 7th cervical rib. Though never, unfortunately, previously published, the Bateman skeleton represents the earliest example of cervical rib to be dissected in these islands, and is accordingly deemed worthy of belated record here.

THE SKELETON OF MARY BATEMAN

The Batemen skeleton is that of an adult, approximately 5 ft. in height: its cranial, thoracic, and pelvic characters are frankly female. Originally all its annectant ligamentous structures were preserved in situ, and the majority, which so remain, include the intervertebral discs and ligaments, the sacro-tuberous, sacro-spinous, and patellar ligaments, both Achilles tendons, and both inguinal (Poupart) ligaments. There is an atlantal bony arch over the vertebral artery and a femoral exostosis about the right ilio-psoas insertion. The finger- and toe-nails are preserved.

The mandible is missing: the calvaria has been removed save for an inch-wide median strip supporting the falx cerebri, which, with the tentorium, remains intact. The dense cranial vault is some 10–11 mm. thick in places: the sagittal and coronal sutures are partly, and the lambdoid not at all, obliterated. (Death occurred at 40–41 years.) The mastoid processes are moderately large; the orbits are empty; the nasal septum and the turbinate bones are intact, as are also the now shrivelled external nasal cartilages. Deep canine fossæ indicate smallish maxillary sinuses; the roomy, well-arched palate is bordered by a full complement of healthy maxillary teeth, exhibiting the modern type of "bite".

The vertebral formula is normal (C.7, Th.12, L.5, S.5, Co.4). No spinal osseous or ligamentous lesion has resulted from the mode of death (strangulation), and indeed remarkably little such damage may occur in modern hangings wherein

the "long drop", with its subaural or submental knot, is employed. The 7th cervical vertebra bears bilaterally a large supernumerary rib, articulating diarthrodially by well-formed head and tubercle with the body and transverse process of that vertebra (*Fig.* 43). The left cervical rib is now lost, but its capitular and tubercular facets on the 7th vertebra remain plainly discernible.

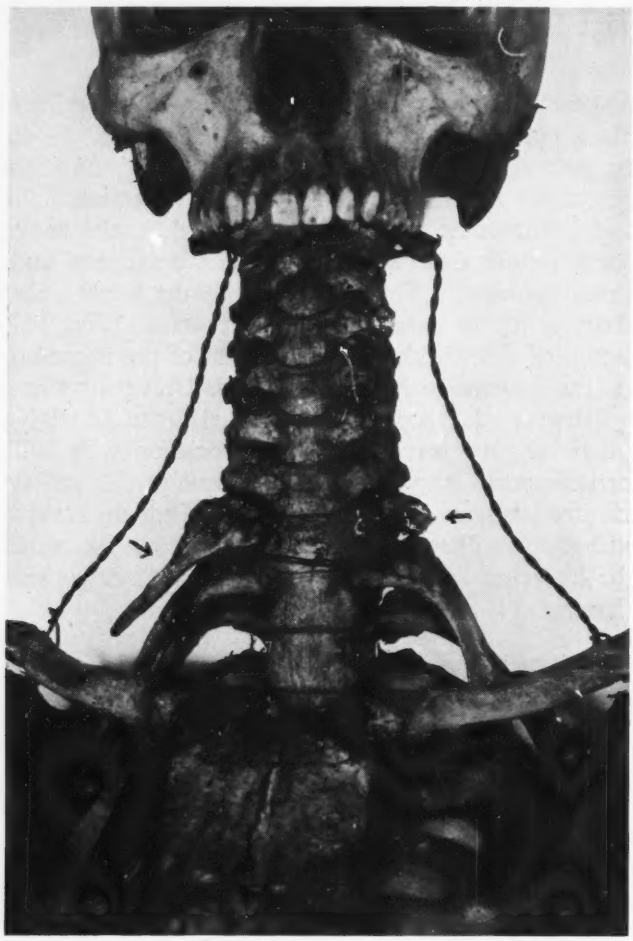

FIG. 43.—Photograph of cervical spine of Bateman skeleton. The right 7th cervical rib remains in situ: the capitular and tubercular facets of the now missing left cervical rib are outlined by chalk marks.

The right cervical rib presents a well-formed head, neck, and tubercle, and a somewhat cylindrical, tapering shaft ending in a free tip distally. From tubercle to shaft-tip the rib measures some 40 mm., and directly from head to tip, 54 mm. The shaft is not disposed strictly parallel to the curvature of the subjacent first thoracic rib, but divaricates therefrom distally. Its tip is independent of direct costal or sternal connexion, although doubtless it originally bore some ligamentous ventral extension. A considerable highest intercostal space must have been present. Neither of the first thoracic ribs reveals any Lisfranc's tubercle, sulcus subclaviæ, or other recognizable secondary marking. The cranial aspect of the supernumerary

rib, however, presents a number of such markings. Thus its neck bears two emphatic grooves, a medial one for the vertebral vessels and a lateral one for the emergent 7th cervical anterior primary division. Its shaft, near the tip, presents a gentle eminence for the attachment of scalene fibres, which separates two distinct if shallow further grooves—one, dorsal to the eminence, for the middle trunk of the brachial plexus, the other, ventral thereto, for the lower trunk. This last and

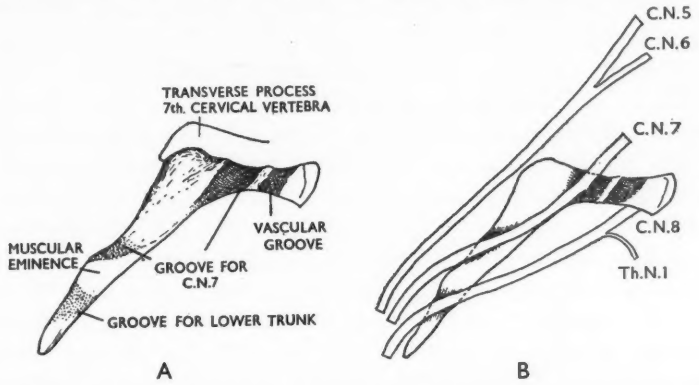

FIG. 44.—The right 7th cervical rib of the Bateman skeleton, to show (A) its features (B) its relationship to the brachial plexus.

most ventral groove extends the entire width of the rib shaft. Apparently the subclavian vessels crossed ventral to the osseous portion of the cervical rib, most probably lying upon its former ligamentous ventral extension. (*Fig.* 44.) The degree of mobility manifested during life by the adventitious costal element is now impossible of assessment, and no record, positive or negative, is now extant concerning possible symptoms attributable thereto.

HISTORY OF MARY BATEMAN

Mary Bateman, born at Aisenby, near Thirsk, in 1768, was the daughter of a small farmer named Harker. Nowise mentally defective, she was addicted to deceit and petty theft from her earliest years, and matured into a cunning and unscrupulous rogue. In 1792 she married an honest, hardworking man (John Bateman, a wheelwright) and spent most of her married life in Leeds, where, to satisfy her insatiate greed for money, finery, and household luxuries, she established herself as a professional soothsayer and fortune-teller. " In this capacity she swindled the credulous by wholesale, and her crimes even to murder were not a few " (Mayhall). Thus she stole money and silverware from a fellow-lodger at High Court Lane: obtained, after a Leeds fire in 1796, large quantities of bed-linen and money, ostensibly for the poor: and even defrauded her own mother of £10 under the pretence of procuring therewith the release of her brother, then arrested for desertion from the Militia. She attracted the foolish and superstitious to her abode in Black Dog Yard, Bank, by exhibiting—at a price—an egg, inscribed " Christ is coming ", reputedly so laid! In 1803 she probably poisoned two maiden ladies named Kitchen, her former mistresses, likewise their mother then visiting the pair: however, Bateman's oracular pronouncement that their deaths resulted from " plague " was apparently accepted, for no legal inquiry was instituted. In her successful and profitable career of soothsaying, trickery, and theft, Bateman professedly had

ghostly assistance in the guise of a certain " Mrs. Moore " and a certain " Miss Blythe, of Scarborough ". That her fantastic claims to alleviate physical suffering and temporal misfortune should have been accorded the credulity they received reflects sadly upon the Yorkshire character. The Perigo murder, however, proved Bateman's undoing. Rebecca Perigo, wife of William Perigo, a small clothier of Bramley, supposed to be labouring under an " evil wish ", sought Bateman's counsel and help. Bateman's pretended powers were exercised for several months, without benefit to any save the soothsayer herself, who meantime had extracted the entire Perigo capital (some £70) besides stripping the foolish couple of their furniture and best clothing. Her victims becoming clamorous in their demands for the promised results, Bateman administered poison (arsenic and mercuric sublimate) to both, in the guise of a secret medicament to be consumed in pudding and honey. Both partook of the alleged remedy, becoming seriously ill. The wife died, but the husband recovered and laid charges against Bateman, who was arrested and committed to the York Assizes. On March 17, 1809, Mary Bateman was tried for the wilful murder of Rebecca Perigo, convicted, and her execution fixed for the next Monday. Her immediate claim to be pregnant was rejected by a jury of " twelve married females " on the ground that the prisoner's youngest child was then but 10 months old! Bateman therefore was duly hanged at York and " Her body was given for dissection to the surgeons of the Leeds Infirmary " (Mayhall), thus providing the subject for the fourth and last of the anatomical courses given thereat by William Hey.

ASSOCIATION WITH WILLIAM HEY

To readers of these pages that distinguished native Yorkshireman, William Hey, F.R.S. (1736–1819), needs no introduction. Aptly did Moynihan (1925) designate him founder of " a dynasty of surgeons " and the begetter of the " Hey-days " of Leeds. Pupil of the immortal Hunter, Hey brought to Leeds the vivifying Hunterian approach to surgery, thus kindling a flame which later hands transmitted undimmed to their successors in turn. He helped found the Leeds General Infirmary (1767), served it as surgeon for 45 years, and anticipated by thirty years the formation of a Leeds medical school by inaugurating, in the spring of 1800, a course of anatomical lecture-demonstrations, repeated thrice in subsequent years. The emoluments derived from these courses were invariably presented to the Leeds Infirmary; subjects were supplied by the hangman at York. The first course (1800) earned £27 6s. for the Infirmary. The second (1803) brought in £40, the subject being one Joseph Heald, executed at York on March 14 of that year for the murder near Wakefield of a Mrs. Elizabeth Smith. (Heald's partner in the crime, John Terry, was dissected by the surgeons at York.) Hey's third anatomical course (1805) produced £45 7s. in fees. His fourth and last (1809) earned the very considerable sum of £80 14s. This last course, obviously well patronized, had for subject Mary Bateman. Now this cadaver was slowly and expertly dissected, repeatedly inspected by a large audience, and the skeleton afterwards most carefully preserved with all its ligaments intact. Consequently the bilateral presence of cervical rib could not have escaped attention at some stage at least of the procedure, and equally could not have failed to occasion comment. It is therefore more than a little surprising—and not a little disappointing to local

patriotism—that Hey published no account of this unusual specimen, which was nevertheless considered worthy of careful maceration and preservation. It is surprising because the anomaly cannot have escaped the single but observant eye of Hey himself, and disappointing because such publication would have been the first of its kind in these islands. For whilst to Hunauld in 1742 is commonly accredited the distinction of the first definite mention of cervical rib, British medical literature lacks any such reference earlier than the first decades of the last century, when Hodgson (1815) and Astley Cooper (1820) each described an exostosis upon the upper aspect of the normal first rib which may have represented the distal end, or the site of articulation, of a 7th cervical rib. Years later, Knox (1843) reported cases of cervical rib, including one with the extra rib articulating directly with the sternum by its own costal cartilage. Later still, Willshire (1860) noted the first (British) occurrence of cervical rib in the living subject, whilst soon afterwards Holmes Coote (1861) observed a left-sided so-called enlargement of the 7th cervical transverse process in a young female. Of these early examples, all appear to be unilateral and some not above suspicion diagnostically. (In 1875 came Struthers's classical paper, listing no less than 13 cases.)

Thus Hey's case (1809), if then published, would not only have taken pride of place in the now considerable literature of cervical rib, but would also have satisfactorily established the occurrence, nature, and possible consequences of this by no means rare condition, almost a century before the work of Stiles, Bramwell, Thorburn, Wood Jones, Wingate Todd, and others focused clinical attention upon it. Any Hey MS. still extant should be searched for possible reference to Bateman's dissection. That her cadaver aroused contemporary curiosity and interest by the unusual features it presented, is witnessed by the deliberate and careful preparation of its skeleton—an attention not bestowed upon the cadavera employed in Hey's earlier courses, and not wholly to be explained by the notoriety of the subject during life.

Bateman's articulated skeleton was long preserved in the old Leeds Infirmary in Infirmary Street. It passed thence to the old Leeds Medical School in Park Street, and therefrom to the new (present) School of Medicine of the University of Leeds in Thoresby Place, where it reposed in the cellarage until transferred by the writer in 1925 to the Anatomical Museum.

Thirteen decades have wrought some damage to the preparation. The mandible is lost, together with the excised portion of the calvaria, the left 7th cervical rib, the right 11th rib, the terminal phalanges of the right medius and of the left 2nd toe, and various right pedal phalanges. The right foot has become detached through ligamentous disruption, which has also affected the shoulder-, elbow-, and hip-joints. Nevertheless the specimen still retains its interest for the anatomist and physical anthropologist, no less than for the student of the medical history of our country, and of the Leeds School in particular.

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CONGENITAL ATRESIA OF THE BILE-DUCTS

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It has been surprising to find practically no reference to the surgery of atresia of the bile-ducts in this country. Probably this is the result of pediatric teaching which, for more than a generation, has passed it by with the comment " entirely insusceptible of treatment "—and this in spite of Thompson's classical description which showed the possibility of operative relief in some cases half a century ago.

AETIOLOGY

The condition is more common in males, only 40 per cent of cases occurring in females, in contradistinction to congenital cyst of the common bile-duct, where 80 per cent of the cases are found in the latter sex.

All congenital abnormalities of the biliary tract can be accounted for either by atypical development or by arrest of normal development, though the cause of this deviation from the normal is unknown. The liver and bile-passages arise in the third week of intra-uterine life as a diverticulum which grows from the ventral aspect of the primitive foregut between the stomach and the yolk sac. This enlarges into the septum transversum and gives off two solid buds of cells, which later form the right and left lobes of the liver, while the more caudally situated cells of the diverticulum proliferate and give rise to the extrahepatic biliary passages. This cellular hyperplasia is so rapid that the lumen is completely occluded until the fourth month, when clefts appear between the cells, and these, joining together, re-establish the lumen shortly before the fifth month, which is roughly a month before bile-pigment is first found in the liver secretions (Ylppo). Irregular cleft formation and atypical fusion may lead to accessory ducts or duplication of parts of the tract, and, if associated with partial atresia, may account for the origin of congenital cystic dilatation of the common bile-duct. Lack of canalization will give rise to complete atresia, partial canalization to partial atresia, which latter may be of three forms: complete obliteration of a part; patency, but considerable diminution in the diameter of the lumen; or a combination of both. That the associated cirrhosis of the liver is not the primary factor, but is secondary, is shown by the lack of progression of the hepatic fibrosis upon relief of the obstruction.

PATHOLOGY

The sites at which congenital obliteration of the bile-ducts has been noted are variable. Holmes, in a review of 120 cases, found that half of these showed complete atresia of the extrahepatic ducts, while in many cases of partial atresia the bile-ducts were found to be occluded in more than one area. In partial atresia when only one area is affected, Walters and Snell suggest the following order of frequency: obliteration of the cystic duct; occlusion of the common bile-duct; and, thirdly, involvement of the hepatic ducts. Two cases are reported of obliteration of the intrahepatic ducts, one being associated with complete atresia

(McClendon and Graham), and the other with normal extrahepatic ducts (Parsons and Hickmans).

When patent, the duct walls may be normal or atrophic, and in some cases definite signs of infection and further resulting obstruction are found. Also, involvement of the duct of Wirsung, with pancreatic atrophy, has been noted in a few cases of atresia of the lower part of the common bile-duct (Holmes).

The liver is invariably involved with chronic obstructive cirrhosis unless the cystic duct and the gall-bladder only are atresic. The spleen is often enlarged, but ascites is rare. Degeneration of the basal nuclei has been reported (Pasachoff).

SYMPTOMS

The presenting symptom is obstructive jaundice, which usually appears in mild form a few days after birth and does not become marked for two or three weeks, but by the second month is of a definite greenish-yellow hue. In spite of the complete obstruction, the degree of icterus varies from day to day, though the urine is always heavily bile-stained and the stools acholic. Nutrition is maintained normally until intercurrent infection or hepatic insufficiency leads to death. The latter is usually shown by the occurrence of spontaneous hæmorrhages.

In certain cases the meconium and even the stools are said to have been bile-stained, but in these the final complete obstruction, either by inspissated secretion or by infection, must have taken place in post-natal life, though it is stated that traces of bile may be excreted by the intestinal mucosa and faintly colour the stools in the deep jaundice of prolonged complete obstruction (Ladd).

DIFFERENTIAL DIAGNOSIS

Icterus neonatorum is very common and is distinguished by the pigmentation appearing first in the skin, then in the conjunctiva, though the latter is rarely affected, and by the presence of bile in the stools.

In the rare condition of icterus gravis neonatorum the blood shows a progressive anæmia with a great excess of nucleated red cells. There is a biphasic van den Bergh reaction and bile is present in the stools. The mortality is high in the first two or three weeks, so that difficulty in diagnosis passes with the lapse of time.

The distinguishing features of jaundice due to sepsis are the marked constitutional disturbance (though the temperature may not be much elevated) and the presence of bile in the stools.

Congenital syphilis can be ruled out by the absence of other clinical features of the disease, radiographs of the long bones, and the Wassermann reaction.

The presence of bile in the stools and the increased fragility of the red blood-corpuscles denote acholuric jaundice.

The diagnosis depends on the persistence of biliary obstruction, hence it cannot be made with any probability until several weeks after the onset of the jaundice.

PROGNOSIS

If the atresia is such that bile is excluded from the intestine, death is inevitable, and usually takes place within six months.

Holmes has pointed out that at least 16 per cent of the cases he analysed were theoretically suitable for operative relief, while Ladd, in reviewing the cases at the

Children's Hospital, Boston, found that 15 out of 40 cases of complete obstruction were operable. He also reports success in 9 of the 15 cases, all of whom " appear to be in excellent health " from six months to ten years after operation.

TREATMENT

Operation should be undertaken in every case, as there is no other way of knowing the type or extent of the obstruction. Analysis of the stools may show lack of pancreatic digestion, in which case one can surmise that the lower part of the common bile-duct, together with the duct of Wirsung, is involved.

The best time to operate appears to be immediately the child ceases to gain weight, for until then the effects of avitaminosis are not apparent and the general nutrition is surprisingly good.

The type of operation depends on the condition found, but choledocho-duodenostomy seems to have given the most favourable results, though anastomosis of either the gall-bladder or the common hepatic duct to the duodenum has been successful.

Concomitant obstruction of the duct of Wirsung does not preclude operation, for children can thrive even with the total loss of pancreatic ferments from the bowel (Graham).

CASE REPORT

HISTORY.—Female, Hospital No. 137842, aged 11 weeks on admission.

Family History: Parents and seven older brothers alive and well; no history of jaundice or deformity.

Patient's History: Full-term child, normal at birth, not breast fed, colour of meconium unknown, birth weight 6 lb. 12 oz. From birth the urine had been dark and the stools light in colour, but jaundice was first definitely observed at the 9th week, and, as it slowly increased, the child was brought to hospital for admission Sept. 27, 1940, when 11 weeks old.

ON ADMISSION.—Well-nourished child, in good condition, but with marked jaundice and acholic stools. Liver slightly enlarged, but edge smooth. Weight 10 lb. 11 oz. Wassermann was negative, blood-counts and hæmoglobin percentage were normal. Weight was slowly gained until Oct. 25, when it was 11 lb. The degree of icterus was variable in spite of completely acholic stools.

Nov. 30.—Blood examination showed:—

R.B.C. 5,330,000.
Hæmoglobin 94 per cent.
W.B.C. 12,000 (Polymorphs 50 per cent; Lymphocytes, 49 per cent).
Fragility test from 0·4 to 0·3 per cent.

Radiograph of abdomen showed some enlargement of liver and spleen and a little gas in the small intestine.

Dec. 3.—Cholecystogram (1 g. per oram), no shadow found.

Dec. 4.—Bleeding time, 2·3/4 min. Coagulation time, 9 min. Given intramuscular bile-salts and vitamin K b.d. for two days.

OPERATION (Dec. 5).—

Anæsthetic: Spinal 0·2 c.c. stovaine, but this was not satisfactory and the operation was performed under open ether.

Operative time: 1 hr.

Incision: Right paramedian, from costal margin to lower margin umbilicus.

Findings: The gall-bladder appeared completely fibrous; the small common bile-duct was found surrounded by a mass of loose fibrous tissue and became completely occluded behind the duodenum. It was impossible to inject saline into any part of the biliary tract to delineate it better, as advised by Ladd.

Procedure: With ophthalmic needles and No. 90 linen thread two stay sutures were inserted into the fibrous tissue around the common bile-duct. The duct was then severed

at the level of the upper border of the duodenum and immediately bile oozed out from the proximal end. The duodenum was then incised, the stay sutures were passed through the incision and from within outwards through the duodenal wall, so fixing some half inch of the duct and its surrounding tissue inside the duodenal lumen. The aperture in the duodenum was then closed with No. 1 silk. A very fine rubber drainage tube was then laid by the anastomosis and brought out through the upper end of the incision, which was closed in layers.

POST-OPERATIVE COURSE.—

Dec. 7.—Taking feeds well, slight cough.

Dec. 8.—Bile from drainage tube, small in amount.

Dec. 9.—Stercobilin present in the stools, which remained coloured until death. Bile drainage from tube ceased.

Dec. 10.—Small protrusion of omentum noted by the side of the tube.

Dec. 11.—Tube removed and the upper half of the incision re-sutured with through-and-through stitches under local anæsthetic.

Dec. 14.—Wound burst completely and child died some two hours after re-suture.

POST-MORTEM EXAMINATION.—The anastomosis was intact and there were no collections of fluid in the peritoneal cavity.

The liver showed advanced biliary cirrhosis, which was confirmed by microscopical sections; the gall-bladder showed a bile-stained cavity of 3 mm. diameter and the cystic duct was extremely small. The hepatic ducts were small and the common bile-duct became a fibrous cord behind the duodenum. The ampulla of Vater and the duct of Wirsung appeared normal. The spleen was slightly enlarged.

Nothing else abnormal was found, though the brain was not examined.

SUMMARY

1. A short account of atresia of the bile-ducts is given.
2. Surgical exploration of every case is urged.
3. A case report is presented.

I wish to thank Dr. J. Rennie, Medical Officer of Health, and Dr. J. Clark, Medical Superintendent, for permission to publish this report; also Dr. K. J. G. Milne, Resident Physician, for allowing me to treat this patient, and Mr. F. J. P. O'Gorman for assisting at the operation.

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THE SURGICAL TREATMENT OF SYRINGOMYELIA

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THE procedure of myelotomy performed in the treatment of syringomyelia is usually referred to as the 'Elsberg-Poussepp operation'. Although Elsberg, in 1916, evacuated a syringomyelic cavity while operating on a case of suspected spinal cord tumour, the first observation on the application of surgery to syringomyelia appears to have been made by Abbe and Coley in 1892, when the cystic swelling in the spinal cord was opened, with subsequent improvement in the clinical condition of the case. Poussepp, in 1926, reported the results of operation in two cases, both showing improvement in symptoms.

PERSONAL CASES

The following ten cases of syringomyelia subjected to surgical treatment have been observed personally both prior to and following operation.

Case 1.—Mark B., was first seen in 1923 at the age of 23 years. During the preceding four years the right hand had been affected with gradually increasing loss of power and he had been unable to appreciate heat over the left leg. Wasting of the small muscles of the right hand had ensued and some weakness of the right leg was now an additional feature. There were no facts of significance in either the past or the family history.

PHYSICAL EXAMINATION (1923) showed inequality of the pupils, the left being larger than the right. The thenar, hypothenar, and interosseous muscles of the right hand were weak and wasted; there was also some slight wasting of the forearm, but movements at the wrist and elbow were good. The right leg was slightly spastic, but all movements were well performed and he was able to walk well. The knee- and ankle-jerks on the right side were brisker than those on the left; right ankle-clonus was present; the abdominal reflexes were absent, and both plantars were extensor, the right being more pronounced. The sensory changes consisted in loss of sensibility to pin-prick and thermal stimuli on the left side of the body, extending upwards from the foot to the level of the fourth cervical segment and, laterally, falling just short of the midline of the trunk (*see* chart, *Fig.* 45). X-ray examination of the cervical portion of the spine revealed no abnormality. A report on the cerebrospinal fluid, obtained by lumbar puncture, showed the following: Fluid clear and colourless; 3 small lymphocytes per c.mm.; total protein 0·035 per cent; a faint detectable trace of globulin; Lange reaction 2 2 2 2 2 2 1 0 0 0; W.R. negative.

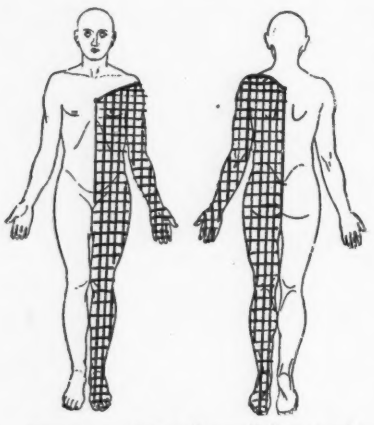


FIG. 45.—*Case* 1. Chart showing area of loss of sensitivity to heat and pin-prick.

OPERATION.—In June, 1926, laminectomy was performed by the late Mr. Bathe Rawling, the laminæ of the 7th cervical and the 1st, 2nd, and 3rd thoracic vertebræ being removed. In the cervical enlargement at the level of the 1st thoracic segment the cord was found to be soft and an incision made at this point penetrated into a cystic cavity. A probe was passed up and down the cavity

for some distance without encountering any obstruction. The contents of the cavity were then evacuated and the wounds closed in layers.

Following the operation there was some degree of shock, and considerable pain in the legs was experienced by the patient. About this time, examination of the urine showed the presence of glucose, and a blood-sugar curve was carried out after the administration of 50 g. of glucose. The result was as follows:

Fasting blood-sugar		0·18	per cent
½ hour	after 50 g. glucose	0·231	„ „
1 hour	after 50 g. glucose	0·256	„ „
1½ hours	after 50 g. glucose	0·300	„ „
2 hours	after 50 g. glucose	0·231	„ „
2½ hours	after 50 g. glucose	0·168	„ „

The urine obtained during the blood estimations was found to reduce Fehling's solution.

Recovery from operation was uninterrupted and the patient, when discharged from hospital, continued under observation in the out-patient department.

Subsequent Progress.—In 1932 he was re-admitted to hospital. There had been no progression of the disease during the intervening period but he had had the misfortune to sustain a fracture of the leg, and as a friend of his, who had also broken his leg, had died as a result, the patient was now in a state of severe depression. A psychological inquiry into his mental condition showed that he had become discouraged largely through reading much about the unfavourable prognosis of his affliction and had become increasingly introspective. After a few months, however, he recovered entirely from his depression. He continued at a steady level both as regards the syringomyelia and his mental state until 1937, when he began to complain of a burning sensation in both hands and feet and that his shoulders seemed as if fixed by a tight band. He suffered from insomnia and the state of mental depression had recurred. Glycosuria had been only intermittent since it was first noted and insulin therapy had not been considered necessary.

Physical examination showed only slight evidence of progress in the syringomyelic process. The right hand and forearm were wasted as before and the right supra- and infra-spinatus, the pectoralis major, and the serratus magnus muscles now showed some atrophy. The deep reflexes of the right arm were present but diminished. There was no change in the condition of the lower limbs, nor in the degree and extent of the sensory disturbance. As before, he recovered from his mental depression after about three months.

A further examination in May, 1940, revealed no change in the syringomyelic process.

Commentary.—In this case the syringomyelia is represented by a Brown-Séquard syndrome, the sensory disturbances being confined to the left side of the body, while the signs of motor involvement predominate on the right side. The patient also showed 'renal glycosuria'. Although operation appears to have had little immediate effect upon the malady, during the fourteen years since it was carried out the progress of the disease has been remarkably slight and is confined practically to the appearance of some wasting in the muscles of the right shoulder girdle. The most recent review of the case suggests that the syringomyelic process is now stationary. It is difficult to be sure whether the relative absence of degeneration is attributable to surgical intervention or to a natural remission of the disease. As the malady was undoubtedly progressing up to the time of operation, it is only reasonable to conclude that surgical treatment may have achieved some success in preventing further extension of the pathological process in the spinal cord.

Case 2.—Miss M. B. was first seen in 1932, at the age of 32 years. She then complained of weakness of the right hand which had been gradually progressing for the previous ten years. Wasting of the affected limb had accompanied the loss of power. Paræsthesia of the right leg was also present. The physical findings noted at that time were wasting and weakness of all the intrinsic muscles of the right hand and absence of thermal and pin-prick sensibility of the right arm and over a zone of the right side of the trunk. During 1937 weakness had also appeared in the left arm and hand and her walking had become impaired. A course of deep

X-ray therapy had been carried out elsewhere five years previously; the treatment had been applied over the lower cervical and upper dorsal region, and as a consequence a dermatitis had developed. The skin had broken down and had healed repeatedly. Her past and family history contained no facts of significance.

PHYSICAL EXAMINATION (July, 1937) revealed a large area of ulceration of the skin, surrounded by a zone of hyperæmia, lying between the two scapulæ and extending upwards

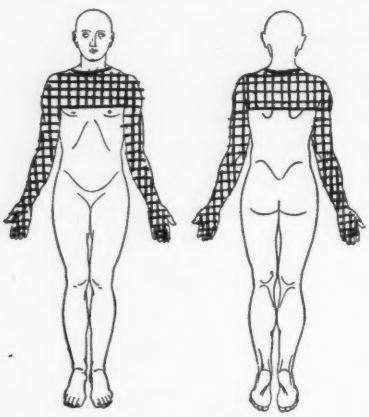


FIG. 46.—*Case* 2 (July, 1937). The shaded area shows the extent of the loss of pain and thermal sensibility.

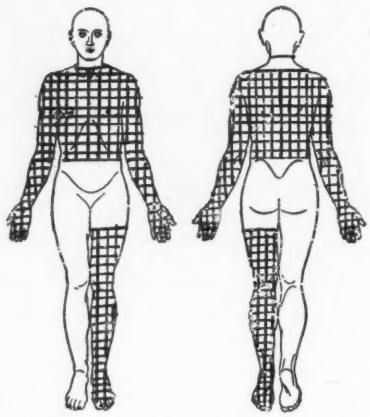


FIG. 47.—*Case* 2 (May, 1939). Showing the extended area of sensory loss.

on to the neck. There was a severe kyphoscoliosis, with convexity to the left. There was some narrowing of the right palpebral fissure and inequality of the pupils, the right being larger than the left. The fundi were normal. The left hand showed *main-en-griffe*; the right hand was somewhat wasted as well as the distal portions of the forearms, with consequent loss of power. The supinator, biceps, and triceps reflexes were absent on both sides; no fibrillary tremors were seen. Both legs were spastic and weak. The deep reflexes were exaggerated but equal, and both plantar reflexes were extensor. The abdominal reflexes were all absent and the gait spastic. Loss of pain and thermal sensibility was present in both arms and extended across the trunk (*see* chart, *Fig.* 46).

Excision of the area of dermatitis was considered impracticable and various local applications were adopted with but little success. The report on a biopsy of a piece of skin removed from the ulcerated region stated that a chronic inflammatory granulation tissue, with fibrosed connective tissue, was present and there was no evidence of malignant metaplasia. Local treatment was continued and after three months the ulceration had healed.

She was re-admitted to hospital in September, 1938. There were no additional symptoms and the motor system was unchanged as compared with its condition in 1937. Some extension of the sensory changes had taken place, however, the dissociated anæsthesia now reaching a lower level. Some blunting to pin-prick was also present over the left side of the face.

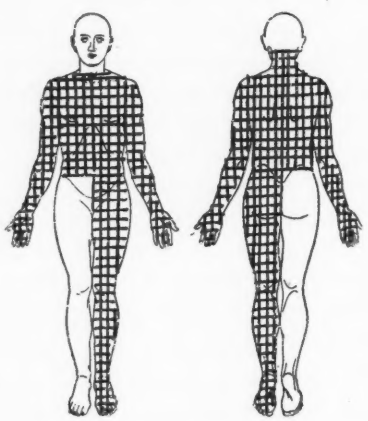


FIG. 48.—*Case* 2 (June, 1940). The area of loss of sensitivity to heat and pin-prick has increased to include the whole of the left side.

OPERATION was performed in October, 1938 (surgeon, Cecil P. G. Wakeley) under gas-oxygen-ether anæsthesia. A midline incision, 8 in. long, was made and the laminæ removed. The dura was exposed over the 6th cervical and the 2nd thoracic segments; a needle was

passed into the syringomyelic cavity and the fluid removed and collected. The dura was then opened and an incision made into the spinal cord extending between the 6th cervical and 2nd dorsal segments. The dura was left unclosed and the muscles and the skin incision approximated with interrupted sutures.

During the period of recovery, some cerebrospinal fluid occasionally escaped through the wound, but at the end of about two months the soft tissues had healed. In May, 1939, a physical examination showed that pain and thermal sensations were not appreciated between the 3rd cervical and 12th thoracic segments and over the left leg as high as the middle of the thigh (*see* chart, *Fig.* 47). Walking had improved considerably. The patient was discharged from hospital in June, 1939.

A pathological report on the fluid obtained from the syringomyelic cavity at operation was as follows : A fluid of slight milky turbidity not clearing after centrifugalization ; 2 small lymphocytes per c.mm. ; total protein 0·025 per cent ; no excess of globulin ; Lange reaction 0 0 1 1 0 0 0 0 0 0 ; chlorides 0·75 per cent ; reduction of sugar normal ; W.R. negative.

SUBSEQUENT PROGRESS.—Observation of the patient was continued as an out-patient. The improvement which followed the operation has not been sustained, as she is now (June, 1940) more readily fatigued on exertion and the limbs are weaker. The muscular wasting is very little altered, but the right leg shows some increase in spasticity and the area of sensory loss is more extensive (*see* chart, *Fig.* 48).

Commentary.—The sensory and both the lower and upper motor neurone systems were all involved in the syringomyelic process. The operation appears to have failed in arresting the disease-process, but it is progressing only very slowly.

Case 3.—G. H., female, aged 45, was first seen in 1932, when she complained of weakness of both hands and of curvature of the back. Since 1929 she had repeatedly burned her fingers but had never experienced pain during these episodes, and it was not until blisters made their appearance that she realized what had taken place. She became aware of weakness of both hands in 1930 ; this loss of power gradually progressed to the extent that knitting and sewing became impossible. During this period her spine had become progressively more curved. There was nothing of significance in either her past or family histories.

PHYSICAL EXAMINATION showed considerable wasting of all the muscles of both arms and especially of the intrinsic muscles of the hands. Sensation to cotton-wool was everywhere normal but sensibility to pain and thermal stimuli was absent in both arms and diminished over the legs (*see* chart, *Fig.* 49). Vibration sense was diminished in both legs. The deep reflexes of the lower limbs were brisk and bilateral extensor plantar reflexes were obtained. There was pronounced kypho-scoliosis.

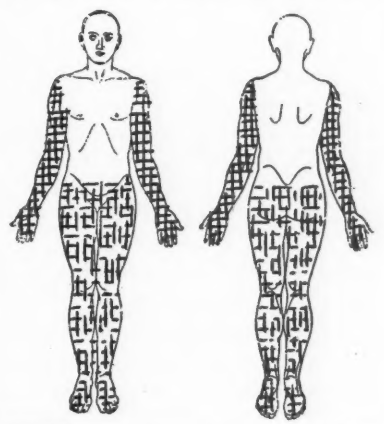


FIG. 49.—*Case* 3. Showing the area of sensory impairment.

An analysis of the cerebrospinal fluid obtained by lumbar puncture gave the following result : Fluid clear and colourless ; 3 small lymphocytes per c.mm. ; total protein 0·12 per cent ; globulin in excess ; Lange and Wassermann reactions negative.

OPERATION.—Cervical laminectomy was performed in July, 1932 (surgeon, Cecil P. G. Wakeley), under gas-oxygen anæsthesia. A large bulge in the spinal cord was demonstrated, and, after the aspiration of 10 c.c. of its fluid contents, a vertical incision was made into its substance and the interior of the cavity swabbed out with iodine. The overlying tissues were sutured and after the lapse of a period of two months healing was complete.

Examination of the fluid from the cavity showed a clear and colourless fluid with no cells per c.mm. ; total protein 0·03 per cent ; and globulin in no excess.

SUBSEQUENT PROGRESS.—The initial improvement following the operation was pronounced but was not maintained after a period of about a year. She was re-examined in 1936, when the syringomyelic condition was found to have remained more or less stationary. In 1939 she developed pneumonia which proved fatal.

Commentary.—This case illustrates an important point. Improvement as an immediate result of operation was undoubted, but its very temporary nature was demonstrated by the subsequent retrogressive course. The conclusion to be drawn is that of the importance of following up a case for a long period before the value of operation can be fully assessed.

Case 4.—The patient, E. H., female, aged 34, was first seen in July, 1931, complaining of weakness in both hands which had first become apparent six months previously. Neither the family nor the past history contained any significant data.

PHYSICAL EXAMINATION showed atrophy of the intrinsic muscles of both hands, with associated loss of power. Loss of thermal and pain sensibility was present over the whole of both upper extremities (*see* chart, *Fig.* 50). The deep reflexes on the right side of the body were increased as compared with the left, and right plantar response was extensor in type.

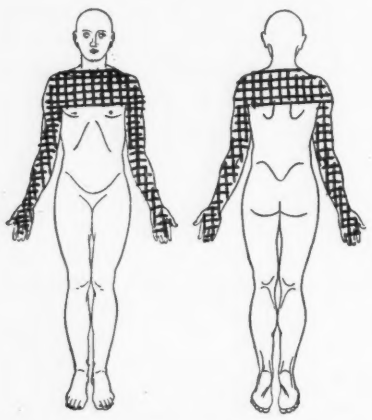


FIG. 50.—*Case* 4. The shaded portions show the area of loss of sensitivity to pin-prick and thermal stimuli.

Cerebrospinal fluid obtained by lumbar puncture showed no deviation from the normal of any of its constituents.

OPERATION was carried out in September, 1931, under gas-oxygen-ether (surgeon, Cecil P. G. Wakeley). The laminæ of the 4th, 5th, and 6th cervical vertebræ were removed and a very dilated spinal cord was exposed; 7 c.c. of fluid were removed from the cavity with a syringe and the dilated cord was incised. The interior of the large central cavity was then swabbed with iodine. The dura was closed with a few interrupted catgut sutures and the overlying muscles sewn up in layers. The wound healed without incident within three weeks.

SUBSEQUENT PROGRESS.—Following operation the degree of power in both hands improved. She was seen again in 1935, when it was found that the improvement had been maintained. The patient was now able to write letters (which before operation she was quite unable to do). She, herself, expressed delight with the result of the operation. The last examination was carried out in December, 1938; progress had been well maintained and the patient was carrying on her occupation as a clerk quite successfully.

Commentary.—The maximum incidence of the disease in this case was in the upper extremities. Improvement was undoubted and the patient has been observed over a sufficiently long period to confirm the satisfactory result.

Case 5.—J. J., female, aged 43, was first seen in May, 1932. Three years previously she had noticed that her hands were becoming deformed and that the two inner fingers were curling up. Within the next year the weakness in her hands increased; she dropped articles repeatedly, and eventually had difficulty in lifting even a cup of tea to her lips. The loss of muscular power gradually extended and the muscles of the arms and forearms became affected, the right side to a lesser degree than the left. On two occasions she had burned herself with a match, but did not appreciate any pain and was only aware of the burn when a blister appeared; this was followed by an ulcer which persisted for several months. The family and past histories contained nothing of significance.

PHYSICAL EXAMINATION showed pronounced wasting of the muscles of both hands, arms, and forearms. The fingers were held in a position of flexion and there were two scars on the palmar surface of the right index finger. There was atrophy of the thenar and hypothenar eminences and of all the interosseous muscles. Sensibility to pain and thermal stimuli was

absent in both arms and over the trunk, but was present in the legs. Sensation to cotton-wool was normal all over the body (*see* chart, *Fig.* 51). Vibration sense was absent in the arms and diminished in the legs, and astereognosis was present in both hands. The deep reflexes of the lower limbs were exaggerated and both plantar reflexes were extensor.

The cerebrospinal fluid obtained by lumbar puncture showed a clear and colourless fluid with 2 cells per c.mm.; total protein 0·04 per cent; no excess of globulin; Lange and Wassermann reactions negative.

Operation was performed in May, 1932, under gas-oxygen-ether anæsthesia (surgeon, Cecil P. G. Wakeley). Following a cervical laminectomy, a large bulge in the spinal cord was exposed. The cavity of the swelling was aspirated with a syringe and 20 c.c. of fluid removed. An incision was then made into the substance of the cord just to the left of the midline to avoid an adjoining blood-vessel. The interior of the cavity so exposed was swabbed out with iodine and the dura mater and muscles sutured in layers. After six weeks the wound had healed soundly.

Subsequent Progress.—Following operation there was an immediate improvement, which was later maintained, as shown by a subsequent examination in May, 1938. The patient stated that she could do much more with her hands than previously and that she did not tire so readily.

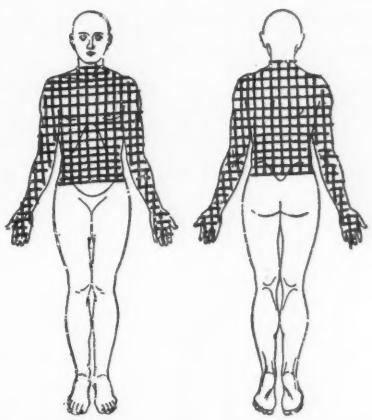


Fig. 51.—*Case* 5. Showing the area of loss of sensitivity to heat and pin-prick.

Commentary.—The result in this case was that of some benefit which was of sufficiently long duration to indicate that myelotomy had been of considerable value. It is also noteworthy that the disease had been steadily advancing prior to operation but had since become stationary.

Case 6.—Dorothy M., aged 26, was first admitted to hospital in December, 1935. In 1927, at the age of 18, she had noticed a loss of feeling in the ring and little fingers of the left hand. This symptom was succeeded by weakness and wasting of the hand and of the arm. The right arm became similarly affected in 1929. She had received a course of deep X-ray therapy at another hospital three years' previously (1932), but this treatment had had no apparent influence on the progress of the malady, which had produced gradually increasing disablement. She now complained of loss of sensation, with wasting and weakness, in both upper extremities. There was also loss of power in the right leg. She had suffered from no previous illness and no history of family disease was obtained.

Physical Examination showed no abnormality of the cranial nerves. There was almost complete paralysis, with advanced muscular wasting, involving practically the whole of both upper limbs, including the shoulder-girdles. A claw-hand deformity was present in the left hand. The right leg was spastic and the muscular power reduced. The deep reflexes were absent in the upper extremities but were exaggerated in the right leg, with ankle-clonus, and the right plantar response was extensor; the abdominal reflexes were absent and the gait spastic. Sensory disturbances consisted in areas of loss to thermal and painful stimuli over the left arm and adjacent portions of the shoulder and neck and over the left hand (*see* chart, *Fig.* 52). Vibration was not appreciated in any of the limbs; deep pressure sense was absent in the right arm and astereognosis in both hands was an additional feature. The cerebrospinal fluid on examination showed no abnormality, the total protein being 25 mg. per cent and the W.R. negative.

Operation.—This was carried out in January, 1936, under gas-oxygen-ether anæsthesia (surgeon, Cecil P. G. Wakeley). The spinous processes of the cervical vertebræ were exposed and the laminæ of the lower spines removed. Following this procedure the dura was seen to bulge considerably, and, on incision, the underlying spinal cord and arachnoid membrane were found to be adherent to one another and to the dura mater. The swelling in the spinal cord was opened, a sample of the fluid it contained being removed for pathological

examination; the cavity was then emptied and its interior painted with dilute iodine solution. The length of the cavity was noted to be 5 in. Finally, the wound was closed in layers.

Report of Fluid obtained from the Cavity.—To the naked eye the fluid was moderately blood-stained, but when centrifugalized the supernatant fluid was found to be clear and colourless. The red blood-cells were normal in appearance and settled as a bright red deposit. On microscopical examination the fluid was found to contain 70 cells per c.mm., mostly lymphocytes and polymorphs—polymorphs 35 per cent, small lymphocytes 56 per cent, small endothelial cells 4 per cent, large endothelial cells 5 per cent; total protein 0·05 per cent; globulin faint detectable trace; Lange reaction 0 1 2 2 1 0 0 0 0 0; W.R. negative.

SUBSEQUENT PROGRESS.—The patient made an uneventful recovery from the operation. She was seen again in June, 1936, when she was found to be three months pregnant. She stated that although she was walking better over short distances—her toes catching less on the ground—she could not walk as far as prior to operation. As both the patient and her husband were most anxious to have a child—their first—the pregnancy was allowed to continue. She gave birth to a healthy male child in December, 1936, after an easy and comparatively painless labour.

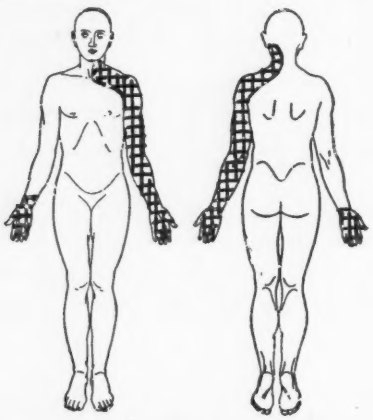


FIG. 52.—*Case* 6 (December, 1933). Showing area of loss of sensitivity to pin-prick and thermal stimuli.

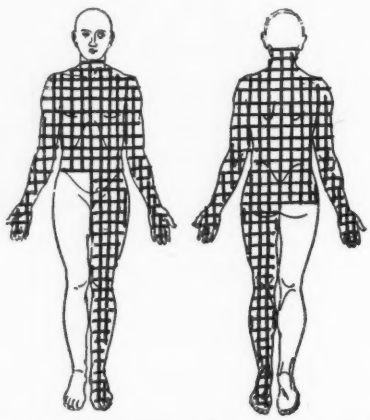


FIG. 53.—Same case (November, 1938), showing the increased area of sensory loss.

The patient was re-admitted to hospital in November, 1938. Physical signs present on this occasion showed the following distinctive features as compared with her condition in 1935. The deep reflexes were brisk in the left arm; in the legs bilateral exaggeration of the deep reflexes with ankle-clonus and a double plantar extensor response were now found. The gait was more seriously affected and she was unable to walk without assistance. Sensory disturbances were now more extensive (*see* chart, *Fig.* 53).

During a third admission in February, 1939, signs of further progress in the disease were found. The right palpebral fissure was narrower than the left and a *main-en-griffe* was now present in both hands, while only over the head and right leg was sensation normal; over the other areas of the body light touch, pain, and thermal stimuli were unappreciated. Vibration, localization, and recognition of shape were all absent, and postural sensibility was only preserved in the left leg. The right foot showed an equinus deformity, chiefly on account of paresis of the dorsiflexors of the foot. A walking instrument was prescribed with some subsequent improvement of gait. Practically no movements were possible in the right arm, and only very slight movement was present in the left. A course of deep X-ray therapy over the involved segments of the spinal cord was administered while she was in hospital, but without improvement. The most recent report of the patient's condition states that she is now confined to bed and quite unable to walk.

Commentary.—The muscular atrophy was of severe degree in this case. Sensory disturbance became very extensive as the disease progressed. It cannot be said that any temporary or permanent benefit resulted from operation and the rapid course of the disease was unaffected by either radiotherapy or surgery.

Case 7.—Edith F. C., aged 57, was admitted to hospital in November, 1935, complaining of weakness and loss of sensation in both arms. Nine years previously her attention had been drawn to the gradual change in shape of her left hand, as the two ulnar fingers were gradually " curling up ". A septic sore developed under her wedding ring and at a later date another on the left thumb. These sores were peculiar in that they were painless and were slow in healing. During the next six months she began to drop things with the left hand and the performance of finer movements became difficult. Weakness and fatiguability of the arms then became increasingly apparent. Five years prior to the date of admission to hospital paræsthesia made its appearance in the affected limbs and two years ago she scalded her right shoulder in a bath but the burn caused no pain. The right hand had also become weak and there was now loss of sensation over both arms and shoulders. Recently, there had also been a tendency to fall.

The only important incident in her previous history was a hysterectomy, in 1924, on account of numerous fibroids.

PHYSICAL EXAMINATION showed unequal pupils, the right being larger than the left; the response to light in the latter was sluggish. There was a slight ptosis of the left eyelid, and weakness of the right sternomastoid and of both trapezius muscles. Her speech was somewhat hesitant. Wasting was present in both deltoids, all the muscles of the left hand, and the right thenar and hypothenar eminences. The fingers of the left hand were extended at the metacarpo-phalangeal joints and acutely flexed at the interphalangeal joints. Marked weakness of grip was present in both hands. None of the deep reflexes in either arm were elicited. The lower limbs showed spasticity, exaggerated deep reflexes, bilateral ankle-clonus, and a left extensor plantar response. The abdominal reflexes were absent. Loss of sensibility to pin-prick and thermal stimuli was demonstrated over the trunk, arms, and legs (*see* chart, *Fig.* 54). Vibration sense was absent over the right leg and diminished over the iliac crests and left malleolus; localization sense and recognition of shape were absent in the body and arms. The appreciation of light touch (cotton wool) was preserved all over the ends.

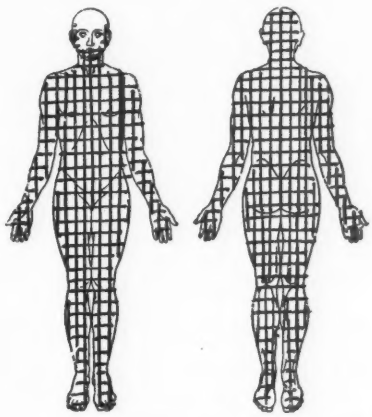


FIG. 54.—*Case* 7. Showing the almost complete loss of sensitivity to pin-prick and heat.

An examination of the fundus oculi showed scarring near both maculæ, more on the right than on the left, and a few discrete spots of pigmentary disturbance towards the periphery of the fundi. It was suggested that the lesions resulted from some form of infection, such as focal sepsis. The visual acuity in each eye was 6/9.

Examination of the cerebrospinal fluid obtained by lumbar puncture gave the following result: Clear and colourless to the naked-eye; 2 small lymphocytes per c.mm.; total protein 0·04 per cent; no excess of globulin; Lange reaction 0 1 1 1 0 0 0 0 0 0; W.R. and Kahn reactions negative. The blood W.R. and K.R. were negative. A radiological examination failed to reveal any abnormality of the cervical spine.

OPERATION.—In December, 1935, a cervical laminectomy was performed (surgeon, Cecil P. G. Wakeley). The dura on incision revealed a bulging spinal cord. The swelling was incised, a specimen of the fluid evacuated being preserved for examination; the internal surface of the cavity was then painted with iodine.

The fluid from the syringomyelic cavity was slightly blood-stained, but clear and colourless when centrifugalized. It contained 2 small lymphocytes per c.mm., with total protein 0·03 per cent; no excess of globulin, and Lange reaction 0 0 1 1 1 0 0 0 0 0.

The patient's condition following operation was satisfactory and she made an uneventful recovery. A further examination carried out prior to the patient's discharge from hospital in February, 1936, showed no alteration in the physical signs.

SUBSEQUENT PROGRESS.—The most recent investigation (May, 1940) of the patient yields the following features: Prior to the operation of December, 1935, she had been able to walk

for a distance of about six miles. During the first year following the myelotomy she was able to walk for only a period of five minutes' duration. In the following year some improvement occurred in this respect and the duration increased to 20–30 minutes. Since then no alteration in her walking capacity has taken place. The sensory changes and muscular wasting have remained in a stationary condition. Physical examination showed slightly increased weakness of the lower limbs, with a bilateral extensor plantar response. The sensory disturbances and muscular atrophy had remained in approximately the same condition.

Commentary.—In this case the clinical features included profound sensory disturbance, spasticity of the lower limbs, and muscular atrophy. Progressive deterioration in her condition had occurred up to the time of operation. Following the latter, some further deterioration was succeeded by a slight degree of improvement; then followed a long period of remission during which the disease has remained practically stationary.

Case 8.—Mrs. H. F. H., aged 38, was first seen in 1930. For four years she had complained of pain and paræsthesia in the right hand, and she had noticed that she was unable to distinguish heat from cold with this hand. Two years later weakness of both hands became evident and she dropped articles readily. Wasting had developed in both hands and had been gradually increasing in degree. There was nothing significant in either the past or family history.

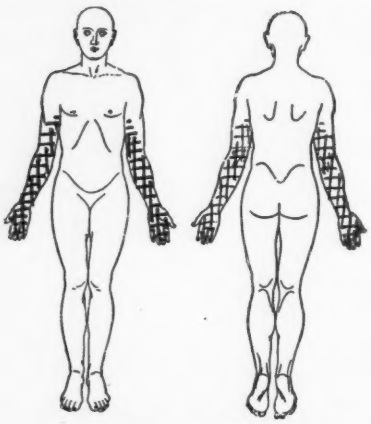


FIG. 55.—*Case* 8. Shaded area shows the extent of the loss of thermal sensibility.

PHYSICAL EXAMINATION showed considerable loss of power in and wasting of all the intrinsic muscles in both hands. Sensory changes consisting of loss of thermal sensibility were present in both upper extremities (*see* chart, *Fig.* 55). The abdominal reflexes were absent and the deep reflexes of the lower limbs were exaggerated on both sides with a bilateral extensor plantar reflex.

OPERATION was performed in May, 1930, under gas-oxygen-ether anæsthesia (surgeon, Cecil P. G. Wakeley). The laminæ of the 5th, 6th, and 7th cervical and the 1st thoracic vertebræ were removed, the dura mater incised and a bulging spinal cord revealed. Of the fluid, 5 c.c. was aspirated from the cavity of the swelling and an incision made in the midline into the spinal cord, exposing the interior of the cavity. The dura and overlying tissues were sutured in layers.

The wound at first was slow in healing, but repair was complete at the end of a month. Sepsis did not complicate the healing process.

SUBSEQUENT PROGRESS.—The patient was seen one year later and stated she considered that operation had improved her condition in that the power of her hands had somewhat increased. In 1935 an examination of the nervous system showed no material alteration in the physical signs, her condition having remained in a stationary state.

Commentary.—The syringomyelic process had shown a steady increase between its date of onset and the time of operation. Since the latter, it had ceased to progress and some slight amelioration of her condition had resulted. It seems fair to assume that the arrest is attributable to the surgical intervention.

Case 9.—Albert H., aged 31, was first seen in October, 1936. He had been well until May, 1935, when he developed an aching pain over the nape of the neck, which spread down both arms. This pain had diminished in severity, but had never quite disappeared. In the following August (1935), a similar type of pain was experienced in the abdomen and was accompanied by a sensation of constriction. This was succeeded by stiffness of the neck, which persisted over a period of six months. Girdle pains, situated just above the iliac crests, made their appearance in June, 1936, and in July, while swimming, he " collapsed

from the waist downwards " and felt as though the lower part of his body was revolving; there was general loss of feeling in the lower extremities, but with some paræsthesia of the toes. Since that date the numbness had remained unaltered and the legs were occasionally affected with cramp-like pains, while the back sweated profusely. Accompanying the disturbance of sensation was some stiffness of legs. Walking became difficult and he frequently lost his balance. Bladder symptoms had also existed since July, 1936; he had to wait for a long time before being able to micturate, while at other times urgency and incontinence of urine were present. Urgency of defæcation and impotence were additional features.

The family and previous histories contained no facts of significance.

PHYSICAL EXAMINATON revealed no abnormality of the cranial nerves and no motor or sensory changes in the upper limbs. The lower limbs showed an increase in muscular tone more pronounced in the right leg, with exaggeration of the deep reflexes and a bilateral

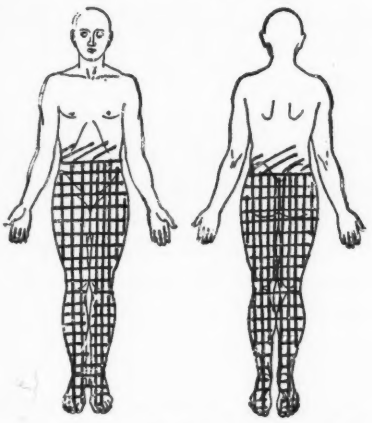
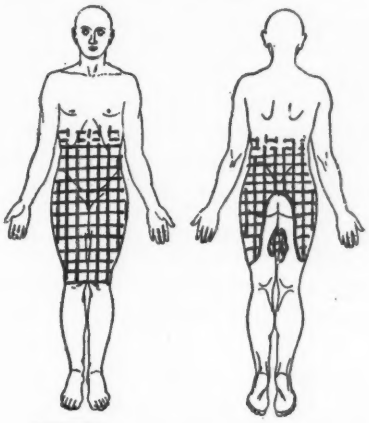


FIG. 56.—*Case* 9. The loss of sensibility to pain and heat extended as far as the umbilicus.



Loss of sensation to pin-prick

Loss of thermal sensibility

Diminished sensibility to pin-prick and thermal stimuli

FIG. 57.—Same case. Showing the changes in sensation following operation.

extensor plantar response. The abdominal reflexes were all absent. Pain and thermal sensibility were not appreciated in either leg, this loss of sensation extending as far upwards as the umbilicus (*see* chart, *Fig.* 56), where a narrow zone of hyperæsthesia was present. Appreciation of cotton-wool and deep pressure was normal, but there was some diminution in vibration and postural sense over the ankles and in the great toes respectively. The gait was spastic, but co-ordination was unimpaired; hyperidrosis was evident over the back. No abnormalities were found in the other systems.

Examination of the cerebrospinal fluid obtained by lumbar puncture gave the following results: To the naked eye, clear, but with a distinct amber-yellow tint; no coagulum on standing; 3 small lymphocytes per c.mm.; total protein 1·12 per cent, with pronounced excess of globulin; Lange reaction 0 0 1 1 2 3 4 5 5 5; W.R. negative. The Wassermann and Kahn reactions of the blood were negative.

Investigation.—A cisternal puncture was carried out, and 1·5 c.c. of lipiodol injected; subsequent X-ray examination showed evidence of obstruction to the descent of the lipiodol. No radiological abnormality was discovered in the 'straight' radiograph. Examination of the cerebrospinal fluid obtained by cisternal puncture gave the following results: Fluid clear and colourless to the naked eye; 2 small lymphocytes per c.mm.; total protein 0·03 per cent; globulin in no excess; Lange reaction 0 0 1 1 1 0 0 0 0 0.

Investigation of the electrical responses in the muscles of the lower limbs revealed no quantitative or qualitative abnormality.

OPERATION.—On January 21, 1939, a thoracic laminectomy was performed under gas-oxygen-ether anæsthesia (surgeon, G. C. Knight). The laminæ of the 7th, 8th, 9th, and 10th thoracic vertebræ were removed. At the level of the 8th lamina, and extending downwards from this point for 1½ in., the spinal cord was seen to be pathological, with convex

distortion of the posterior median artery to the right by an ovoid and yellow expansion on the left side of the cord. The substance of the cord was incised over the distended portion and in the centre a cystic cavity containing yellow fluid was demonstrated. An incision was made into the cyst and the fluid contents evacuated; the cavity was found to extend over a length of 2 in. A second smaller cystic swelling at a higher level was also incised and evacuated. The interiors of both cavities were painted with 5 per cent iodine solution and the wound was closed in layers, leaving the dura open, as closure of the latter tended to compress the spinal cord.

SUBSEQUENT PROGRESS.—The patient made a good recovery from the operation and left hospital in February, 1937. He has since attended the out-patient department, where periodical re-examinations have been made. His gait has gradually improved and he now walks very well, although he is unable to run and slight stiffness of the legs still persists. He can walk a distance of about a mile without resting. There is no sensation of actual numbness, but he thinks the "feeling" in his feet is defective. Some urgency of micturition and defæcation persists. The most recent physical examination (May 1940) shows some spasticity of both lower extremities, with exaggerated deep reflexes and a bilateral extensor plantar response. The abdominal reflexes are absent. The changes in sensation are shown in the accompanying chart (*Fig.* 57).

Commentary.—The clinical features of the case, consisting of a spastic paraplegia and dissociated anæsthesia below a certain level, are those which might be expected from compression of the spinal cord. The abnormal findings in the cerebrospinal fluid obtained by lumbar puncture as contrasted with the normal fluid resulting from a cisterna puncture are additional factors which support this contention. Pronounced improvement has resulted from the operation, and has persisted over the succeeding period of a year and a half.

Case 10.—J. A., male, aged 40, was seen in 1931 with a history of pain in both arms which had begun ten years previously. For about six months prior to admission, he had experienced numbness and loss of power in both hands (the notes on the history of this patient are incomplete).

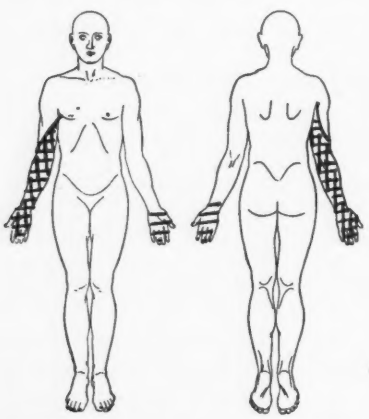


FIG. 58.—*Case* 10. Showing the areas of loss of sensation.

PHYSICAL EXAMINATION in 1931 showed wasting of all the small muscles of both hands, the right being affected to a greater extent than the left, and showing a tendency to a claw-hand deformity. There was considerable impairment of sensibility to pain and thermal stimuli over the right arm, while pin-prick was not appreciated in the left hand (*see* chart, *Fig.* 58). The abdominal reflexes were present; the legs were spastic and the deep reflexes of both lower limbs were all exaggerated but equal on the two sides. The left plantar response was extensor, the right being flexor.

OPERATION was carried out under gas-oxygen-ether anæsthesia in July, 1931 (surgeon, Cecil P. G. Wakeley), when the laminæ of the 4th, 5th, 6th, and 7th cervical vertebræ were removed. A dilated cord was exposed, and on incision numerous cavities were found to be present. The fluid contained in the cavities was evacuated and the wound sewn up in layers.

Following the operation the patient developed pneumonia and the wound became infected. The organisms found in the lung and wound proved to be streptococci. Death occurred on the sixth day following operation.

Commentary.—The pneumonic process can probably be explained as a complication of the general anæsthesia given, since it occurred within such a short interval after the operation. No difficulties were experienced during the actual administration of the anæsthetic.

AETIOLOGICAL AND PATHOLOGICAL CONSIDERATIONS

The term 'syringomyelia', signifying the formation of a cavity within the spinal cord, was introduced by Ollivier in 1824. The name, however, gives no indication as to the nature and origin of the cavity, and some confusion exists as regards the precise conditions to which the term should be applied. Cavities in the spinal cord which depend upon infective, vascular, neoplastic, and other extrinsic causes are more properly placed in the category of 'secondary syringomyelia' (Worster-Drought and Shafar, 1940) while 'syringomyelia' employed in the usual clinical sense is a separate entity and should be regarded as a disease *sui generis*.

Some appreciation of the pathological process in syringomyelia is essential for an understanding of the rationale and the evaluation of the surgical operation. Our knowledge of the various aetiological and pathological factors in the disease, however, is still incomplete. The prevalent conception of the aetiology is that the cavitation results from a congenital abnormality, closure of the neural tube for some unknown reason being imperfect; consequently, cellular genesis is deranged and embryonic nests of primitive cells persist into adult life, when they undergo multiplication and subsequent degeneration and liquefaction. The fact that the primary lesions are invariably to be found in that area of the spinal cord which it occupied by the central canal lends support to this view. Congenital abnormalities which often include one or more of those anomalies classified by Bremer (1926) as 'status dysraphicus' are common concomitants and furnish additional evidence in favour of this theory. Multiple cavities not infrequently occur in one and she same case, and their presence is difficult to explain on any other hypothesis. The occasional development of tumours in the gliotic cavities do not necessarily furnish an argument against a congenital origin of the disease (Putman and Munro, 1931). Two processes are essential features of the morbid condition. The first—glial proliferation—is apparently the fundamental lesion. The cell concerned is of a relatively benign, adult type, as its growth is slow and its infiltrative power is low; this suggests that the glial cell concerned is the astrocyte, although another possibility exists in the ependymal cell, tumours of which—ependymomas—as well as astrocytomas, may become cystic (Grinker, 1937). Cox (1938) suggests that portions of ependymal tissue may become segregated and undergo independent maturity. Mackay and Favill (1935) consider that, pathologically, syringomyelia is based on a malformation of the median raphe of the medullary tube, a primary ependymal gliosis centering in this raphe; mesodermal tissues may also be included within the abnormal process. These authors state that the glial cells arise from the germinal cells of the medullary epithelium which also produces the ependymal. Consequently, the germinal cells may give rise to an ependymal neoplasm in one part of the spinal cord, while producing syringomyelia in another portion. Those tumours other than gliomas which are occasionally encountered in association with the disease are explained by the malignant growth of the heterotopically included tissue in the medullary tube at the time of its closure.

The second feature of the morbid process characteristic of many cases of syringomyelia is that of cavitation. The formation of cavities is apparently due mainly to the inherent tendency of the abnormal glial tissue to liquefactive disintegration. Another possible factor is that of vascular changes in the periphery of

the growing mass. Mackay and Favill refer to the increase in the number of blood-vessels and in the thickness of their walls in the peripheral portions of the gliosis. Wilson (1940) mentions changes in the surrounding blood-vessels which include a reduction in their number, hyaline changes in their walls, and even occlusion. Reduction of blood-supply may thus be a cause of impaired nutrition and of consequent necrosis of the affected glial cells, which then undergo liquefaction. The cavity present may represent to some extent the original defect in the formation of the septum (Mackay and Favill).

Whatever the cause of the cavitation, however, it must be emphasized that cases occur which represent the extremes of a scale extending from areas of mere gliosis to extensive cavitation. Thus, in some cases an area of gliosis may be the sole abnormality, while in others all the glial tissue appears to have been absorbed in the formation of the cavity. Autopsies have revealed areas of gliosis in the spinal cord which have given rise to no clinical manifestations; similarly, small cavities have been found whose presence was not suspected during life. Ssoson-Jaroschewitsch (1931) distinguishes between a 'dry' and a 'wet' variety of syringomyelia, the difference depending upon the predominance of gliosis or cavitation respectively. In the 'dry' variety the prognosis is considered to be unfavourable, while the 'wet' form is that which is more likely to benefit from surgical treatment. This author considers that the 'wet' form of syringomyelia can be diagnosed clinically by signs of subarachnoid block. While this observation is probably correct with regard to some cases, it should be realized that only a grossly distended spinal cord gives rise to the clinical features of spinal subarachnoid obstruction, including noteworthy increase in the total protein of the cerebrospinal fluid (*Case* 9), while extensive cavitation may be present within the spinal cord in their absence (*Cases* 4, 6).

The clinical signs of syringomyelia include disturbances of the various forms of sensation and particularly the characteristic dissociated anæsthesia; muscular atrophy and paresis, especially of the upper limbs, and spastic weakness of the lower extremities. The sensory changes result from interference with those nerve-fibres subserving sensation which cross in the commissures of the spinal cord, while degeneration of the anterior cornual cells and involvement of the pyramidal tracts explain the muscular atrophy and spastic paraplegia respectively. It is easy to appreciate how an area of gliosis within the spinal cord interrupts the path of the nerve-fibres passing upwards from below, but the manner in which syringomyelic cavitation gives rise to the symptoms and signs observed may be more complicated. The cavity usually contains fluid, which, as mentioned previously, may be either clear and colourless or show a yellow tinge. This fluid is probably formed by the liquefactive disintegration of glial cells, and may be augmented by some secretory activity of the cells lining the cavity or by a process of osmosis attracting fluid from surrounding tissues. The most important factor, however, is the pressure within the cavity. Should this pressure be less than that of the structures immediately surrounding the cavity, the symptoms and signs of the disorder depend entirely upon the local destruction of nervous tissues and glial overgrowth. If the pressure within the cavity is greater, however, the long tracts of the spinal cord will be compressed and a pressure necrosis may occur in the tissue at the margin of the cavity, while an œdematous process in the vicinity will add to the extent of the lesion. Also, the local blood-supply will be impaired and as vascular changes

may also occur, such effects will tend to augment the pathological process. No therapeutic measure can be expected to bring about regeneration of atrophied nervous tissue, nor can myelotomy influence an infiltrating gliosis. All that can be hoped for from operation is the relief of pressure within the syringomyelic cavity and the attempt at measures which will prevent re-accumulation of fluid. Theoretically, therefore, removal of the fluid contents of the cavity will be of value only in those instances in which a high internal pressure exists. It is usually impossible to distinguish between those symptoms and signs which result from gliosis and those due to cavitation. Although physical signs of a transverse lesion of the spinal cord are suggestive, the only indisputable evidence of a greatly distended cavity is a change in the composition of the cerebrospinal fluid—definite increase in the total protein without notable increase in the number of cells, and occasionally xanthochromia (Froin's syndrome), or a ' hold-up ' at a particular level of lipiodol injected through a cistern puncture. On the other hand, the tension within a syringomyelic cavity may be quite high without producing these features.

It is not proposed to compare the merits of radiotherapy with those of surgery. All productive or proliferating tissue is radio-sensitive, and, consequently, it is reasonable to expect some response in the abnormal glial tissue to deep X-ray therapy. This treatment, however, can have no direct effect on cavitation, and might indeed tend to increase the fluid contents (Radding and Forrestière, 1937, and O'Brien, 1935). In sharp contrast is the claim that even a spinal subarachnoid block can disappear after a course of deep X-ray therapy (*Lancet*, 1935).

REVIEW OF LITERATURE

A perusal of the recorded instances of syringomyelia which have been subjected to surgical treatment give a favourable impression as to the results obtained. Careful scrutiny, however, raises doubts concerning at least some of the cases, as the periods over which they have been observed following operation have been too short ; in many instances this period has been less than a year. Such case reports provide information on the immediate effect of operation, but do not yield evidence as to the ultimate influence of surgical treatment on a disorder that continues for many years. This fact is well emphasized in the reviews of Schaeffer (1932) and of Ley (1934)i. Adelstein (1938) collected from the literature 120 cases of syringomyelia in whch operation has been performed, and added 3 personal cases ; he found that 66 appeared to have derived benefit. A possible fallacy exists in the tendency to publish only successful results. The criticism might be advanced, therefore, that such figures give an erroneous impression. Davis (1936) expresses a similar opinion, while Kelly (1935) was disappointed with the results of operation in his series of 10 cases.

OPERATIVE TECHNIQUE

It is frequently stated that cases of syringomyelia are bad subjects for general anæsthesia. The use of gas-oxygen-ether anæsthesia has been preferred by us, as local anæsthesia produces œdematous cutaneous structures which are more liable to become septic ; also, the possibility of sudden movements of a conscious patient is avoided. In none of our cases were any difficulties encountered, either during induction of anæsthesia or during the actual operation ; one case, however, developed what appeared to be a post-anæsthetic pneumonia which proved fatal.

Absolute asepsis is essential, but the application of strong antiseptics is to be avoided. In the preparation of the skin, the best results are obtained from the use of ether soap and spirit. A straight incision from the foramen magnum to the 7th cervical vertebra is made and the erector spinæ muscles retracted from the spinous processes. Absolute hæmostasis is all-important. The spinous processes and laminæ over the site of the cavity are removed and any bleeding from exposed bony surfaces is controlled with bone wax. The dura mater after incision is retracted by means of fine peritoneum forceps clipped to the cut surface of the membrane

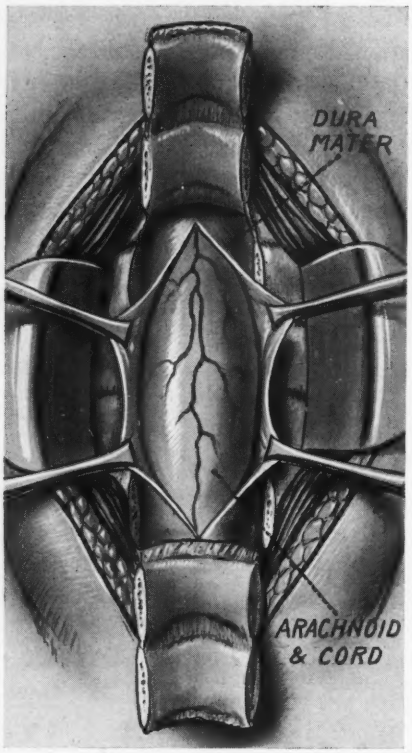


FIG. 59.—Showing the dura mater retracted by fine peritoneum forceps.

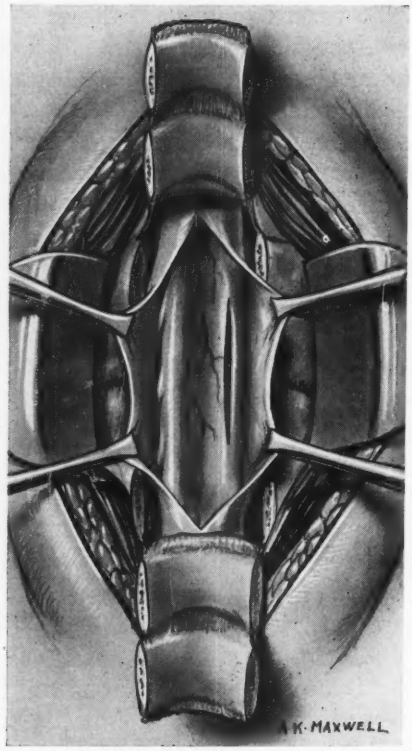


FIG. 60.—The incision into the cord, made to one side of the midline to avoid the central longitudinal vessel.

(*Fig.* 59). Aspiration of the cavity or cavities by means of a needle and syringe allows of examination of the contained fluid. The incision into the cord should be made just to one side of the midline in order to avoid the central longitudinal vessel so frequently found in that situation (*Fig.* 60). Great care must be exercised in exploring the syringomyelic cavity as its walls are often thin and fragile. Having drained the cavity of its fluid, the walls should be lightly painted with a $2\frac{1}{2}$ per cent solution of iodine in spirit and the walls of the cavity allowed to fall together. The incision in the dura is closed with one or two sutures, this procedure allowing drainage of cerebrospinal fluid for a period. Every care must be taken to repair the muscles, which are sutured in layers; absolute union is essential for the prevention of any escape of cerebrospinal fluid through the opening in the muscles. The skin is sewn together with interrupted silkworm-gut sutures, which are left in for fourteen days or longer.

The patient is nursed in the sitting position, and all pressure should be removed from the region of the wound in order that there may be no interference with healing. As healing in all cases of syringomyelia is notoriously slow, after removal of the skin stitches the wound may fail to show evidence of satisfactory repair. On this account a very thorough aseptic technique is most important. It has been suggested that sulphonamide should be administered orally as part of the operative régime in an attempt to ensure that no infection occurs in the wound. The risk of sepsis is very great, as it has been estimated that 25 per cent of cases of syringomyelia subjected to operation die as a result of septic meningitis (*Lancet*, 1935).

The objectives of surgical treatment in syringomyelia are to relieve tension within the syringomyelic cavity, thus reducing the effect of pressure and œdema on adjoining areas of the spinal cord, and to prevent the re-accumulation of fluid inside the cavity. The former purpose is applicable only to suitable cases, while the latter may be achieved by one of two possible methods :—

1. A permanent opening which allows a direct communication between the interior of the cavity and the subarachnoid space. Various means have been suggested, such as silver clips (Gardner, 1934), muscle tissue (Schaeffer, 1932), or the suturing of the lining membrane of the cavity to the arachnoid on each side (Mixter, 1936). In those cases which have been operated upon a second time, however, the original opening in the spinal cord has been found to have become closed by a plastic arachnoiditis (Frazier, 1930).

2. Obliteration of the syringomyelic cavity. The evacuation of the fluid contents of the cavity causes its walls to collapse, and if the interior is painted with iodine solution, the contact between the anterior and posterior internal surfaces of the cavity is maintained by the resulting fibrosis. This is the procedure adopted in our cases.

INDICATIONS FOR OPERATION

The difficulty of ascertaining which symptoms are referable to gliosis and which to cavitation renders the indications for operation uncertain. In cases showing a definite subarachnoid block, operation is necessary as a therapeutic measure and for the establishment of diagnosis. Investigation of the cerebrospinal fluid and X-ray examination following the suboccipital injection of lipiodol is of great assistance in identifying such cases. Feiling (1935) suggests that surgical treatment should be adopted when pain of severe degree is present. Pain in syringomyelia is a relatively infrequent symptom, most cases running a painless course throughout. In some cases, however, pain may be a persistent feature, and apparently results from irritation of the intramedullary pain tracts or involvement of the dorsal horns of the grey matter of the spinal cord (Parker, 1930). None of our cases experienced pain of any severity.

ANALYSIS OF PERSONAL CASES

Although a short commentary has been added to each of the cases we have reported, it is necessary to consider the series as a whole, and below is given a table summarizing the results. No example of septic meningitis occurred in this series. It can be stated that radiotherapy appeared to have little, if any, effect in the cases submitted to this form of treatment. In no case was a second operation performed on the spinal cord.

The results of surgical treatment can be divided into the immediate and the remote effects. With regard to the former, one can judge the effect on the symptomatology of the release of fluid from the syringomyelic cavity. The assessment of the remote results is more complicated as syringomyelia is a chronic disease in which long periods of remission may occur. Should the condition have been steadily progressing prior to operation, and if, following surgical treatment, some arrest in the progress of the malady is noted over a reasonably long period of observation, it is only fair to conclude that operation has had a beneficial effect. Such arrest or improvement may be included under the heading of remote results.

Table I.—SUMMARY OF DETAILS OF PERSONAL CASES

CASE NO.	SEX OF PATIENT AND AGE AT OPERATION	COURSE OF DISEASE PRIOR TO OPERATION	IMMEDIATE RESULT OF OPERATION	SUBSEQUENT PROGRESS OF DISEASE	PERIOD OF OBSERVATION SINCE OPERATION	CONCLUSION
1	M. 26	Progressive	No improvement	Practically stationary	14 yr.	Operation apparently successful in arresting disease
2	F. 38	Progressive	Some improvement	Slow deterioration	8 yr.	Unsuccessful
3	F. 45	Slowly progressive	Improved	Later progressive and then stationary	7 yr.	Initial improvement followed by deterioration and later a remission
4	F. 34	Slowly progressive	Improved	Improvement maintained	7 yr.	Successful
5	F. 43	Slowly progressive	Improved	Stationary	6 yr.	Successful
6	F. 27	Rapidly progressive	Not improved	Steadily progressive	8 yr.	Unsuccessful
7	F. 57	Slowly progressive	Aggravated	Stationary following aggravation	5 yr.	Doubtful; deterioration after operation, then stationary
8	F. 38	Slowly progressive	Improved	Stationary	5 yr.	Successful
9	M. 33	Progressive	Definitely improved	Stationary	1½ yr.	Successful
10	M. 40	Progressive	Died 6 days after operation from post-anæsthetic pulmonary complication			

EVALUATION OF SURGICAL TREATMENT

The evaluation of surgical treatment in syringomyelia is an extremely difficult problem and one which can be satisfactorily determined only as the result of the analysis of a large number of cases. The first essential is the selection of suitable cases, and reference has already been made to some of our limitations in this respect. It is a justifiable conclusion that surgery is not indicated in mild or stationary syringomyelia, and only those cases in which the disease is obviously progressing should be considered. The sex and age of the patient and the preoperative duration of symptoms appear to have little influence on the course of the disorder (Frazier and Rowe, 1936). Our knowledge that the natural tendency of the disease is to progress slowly (except in a few cases complicated by hæmorrhage into the cavity), and possibly to be interrupted by periods of quiescence, is a further reason for advising a conservative outlook towards surgical measures. An

example of a remission which lasted for a period of twenty-four years is reported by Taylor, Greenfield, and Martin (1922). Multiplicity of cavities is yet another factor requiring consideration in determining the advisability of operation. The latter carries with it a relatively high mortality-rate due mainly to the frequent incidence of septic complications; this and the delay in the healing of wounds in the subjects of syringomyelia are additional factors to be taken into account. It may be said that only after careful observation and consideration of each progressive case individually, bearing in mind that the disease is liable to spontaneous remissions, can the advisability of operation be determined.

SUMMARY

1. Ten cases of syringomyelia in which the operation of myelotomy has been carried out are described and the results assessed.

2. Aetiological and pathological considerations and the indications for operation are discussed.

3. The surgical technique employed is described.

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LEONTIASIS OSSEA

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LEONTIASIS ossea was the name given by Virchow[1] in 1896 to the condition of hyperostosis of the facial and cranial bones. The term 'leontiasis' had long been used to describe the nodular changes in the soft tissues of the face seen in certain cases of leprosy. It was the similarity in appearance of the patients, and not any underlying pathological resemblance, that provoked Virchow to coin the name. He considered the condition comparable to elephantiasis of the soft tissues. The disease has also been termed 'megalocephaly' and 'hyperostosis of the skull'.

The earliest pictures of the disease were based largely on the skulls in museum collections and were very incomplete, particularly as the skeletons were rarely available for comparison. In 1899 Sternberg[2] was able to collect the clinical records of 12 cases, three of which were later proved to be other conditions—one syringomyelia (Hale-White[3]), another Paget's disease (Edes[4]), and the third syphilis (Putman[5]). In 1923 Lawford Knaggs[6] published a very full review of the subject, based chiefly on an examination of the various well-known specimens which were available in the museums of this country. He considered 21 cases and decided that they were divisible into two main groups—the cases of creeping periostitis which practically always commence in the nasal fossæ or the sinuses and are characterized by the laying down of large deposits of new bone subperiosteally, and those of diffuse osteitis in which the inflammatory changes are limited to the medulla of the bones. He believed that the cases of diffuse osteitis were really examples of osteitis fibrosa occurring in the bones of the skull and face.

Since Lawford Knagg's paper in 1923 only about 25 cases of leontiasis ossea have been published, most of these being in France and America. It is probable that the condition is not so rare as this would indicate, but rather that the difficulty of the subject has discouraged publication of cases. This difficulty lies particularly in the separation of leontiasis ossea as a distinct clinical entity from the other bone diseases—in particular Paget's osteitis deformans and osteitis fibrosa.

AUTHOR'S CASES

Case 1.—**Advanced case of leontiasis ossea associated with scoliosis and kyphosis with secondary osteo-arthritis of the spine and multiple rodent ulcers.**

The patient, J. A., a male aged 54, was first seen on Nov. 4, 1940 (*Fig.* 61). His family history was good, his father died at the age of 84 and his mother at 83, with no history of bone trouble on either side. He has one daughter and three sons, ranging in ages from 6 to 22, and none has shown any abnormality of the bones.

He presented himself for treatment of an ulcer of the left leg. The ulcer was 1¼ in. in diameter and had raised, hard edges like an epithelioma. It had been present for twelve months and was situated midway between the knee and ankle on the inner side of the left leg. It was removed, and the section, to our surprise, showed an ulcerated basal-celled carcinoma or rodent ulcer (*Fig.* 62).

The patient gave the following history of the head condition: His childhood had been normal except for a severe blow with a 'duck-stone' (a large flat pebble used in the game of knocking down piles of stones) on the left maxilla when he was 8 years old. The injury was not severe enough to keep him in bed, but the face was very painful for some months. A photograph (*Fig.* 63) taken shortly after this accident shows a definite prominence of the left maxilla and a widening of the distance between the eyes. As the left maxilla is now the most prominent part of his face, he thinks that the injury was an important causal factor. In spite of this, he alleges that his head, though large, was "normal" until 1923. Actually, in 1915, he was rejected for the army (C3) because of his abnormal head. He has had no other illness of any importance.

After leaving school he worked in a brickyard, doing heavy work, until 1918; and from then until 1923 in a cotton mill bagging waste, again fairly heavy work. From 1923 onwards he has done no regular work, but has been able to look after poultry and help in

FIG. 61.—*Case* 1. This picture gives an idea of the size of the patient's head in relation to his trunk. Note the small hands holding the very large cap.

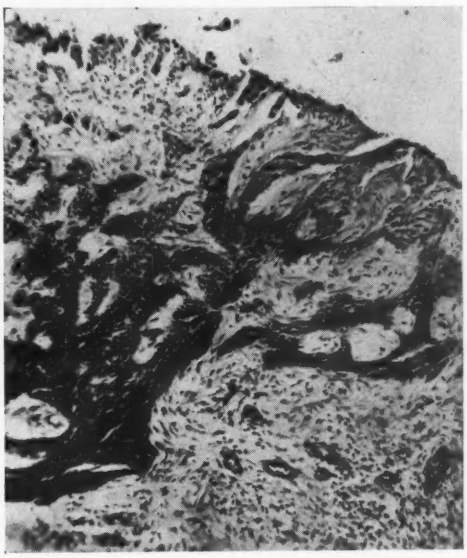

FIG. 62.—*Case* 1. Photomicrograph of section from ulcer on left leg. Basal-celled carcinoma.

domestic duties for most of the time, the notable exception being the year 1923, when he was very ill with "bronchitis" and "neuritis all over his body". By neuritis he meant severe pains in the head, trunk, and all four limbs. At this time he had a series of attacks which his doctor called "slight strokes". In these attacks he lost consciousness, but never had convulsions or residual paralysis.

On examination the striking feature was a small man, 5 ft. high, with a huge grossly deformed head (*Fig.* 64). So frightening was the deformity that, on arrival at the Out-patient Department, a nurse immediately put him in a side room away from the other patients. Even so, one woman who met him in the hall broke down and caused quite a scene. He had, however, travelled to hospital by bus and did not seem unduly self-conscious about his affliction. He had never been to hospital before and accepted his disability as the will of God.

The facial bones appeared to be affected to a greater extent than the calvarium. The right maxilla alone had been missed by the disease. As the left maxilla showed the largest boss, this aggravated the asymmetry of his face. The right maxillary antrum was translucent, the left opaque. There were huge bosses expanding the mandibles. His teeth were bad and many had been irregularly displaced. Similarly, the immense increase in the left maxilla encroached on the mouth and carried one of his teeth so far inwards that it appeared to be suspended from the middle of the palate (*Fig.* 65). As a result, his teeth did not approximate

on closing his mouth. He was able to eat ordinary food with little difficulty, but his jaws soon ached.

His head has increased enormously in size. As a young man he wore hats " less than 7's ". The circumference of his head is now 28¼ in. (For comparison, a size 7 hat fits a head of approximately 22 in. circumference; 21 in. is said to be average. The record circumference, as far as can be determined, is the Bristol skull of leontiasis ossea—31¼ in. (Stack[7]).

His weight, dressed, is 114 lb. Before his illness in 1923 it was 124 lb.

The bones of the face and skull can be felt as rough irregular surfaces beneath the skin. Over the anterior part of each parietal bone there is a depression about 2 in. in diameter. The patient is emphatic that these depressions disappear when he lies down for some hours, but we have not had an opportunity to confirm this. These depressions are merely less thick areas of the skull and not actual defects. The patient, however, is firmly convinced that

FIG. 63.—*Case* 1. Photograph of patient at age of 8 years. Note the prominence of the left maxilla and wide separation of the eyes.

FIG. 64.—*Case* 1. Full-face photograph. Note gross deformity, most marked in left maxilla. Right maxilla not involved. The wide spacing of the eyes and the narrowing and elongating of the palpebral fissure are well shown. Rodent ulcer on the left upper eyelid is clearly seen.

when these areas " come up " he is relieved, and when they sink in, his frontal headache is aggravated. Of course, this is another way of saying that his headaches are easier when he lies down.

His eyes have been displaced laterally and the stretching of the skin over his cheeks has elongated and narrowed the palpebral fissures. There is no exophthalmos nor proptosis. There is no epiphora. His vision is very defective. With the right eye he could distinguish shadows at one foot. The sight of his left eye was 3–60. He has never worn glasses for obvious reasons. His sight does not worry him indoors, but he finds it trying in traffic.

His hearing is normal on the right side and slightly subnormal on the left. He has never suffered from head noises nor heard any murmur in the carotid such as is described from narrowing of the canaliculus caroticus.

He has now no nasal obstruction, but this was a most troublesome feature in 1923. In fact, this seems to have been the chief feature of his " bronchitis ". At one phase he was a mouth-breather entirely, but recovered spontaneously in 1924. He is subject to frequent colds, but there is no nasal discharge; smell is impaired; taste is normal, and he enjoys smoking.

Severe paroxysmal headaches, relieved by analgesic tablets, have been a feature throughout his illness. He has frequent attacks of trigeminal neuralgia and, in particular, aching of the gums. This may be in part due to his bad teeth. There is no facial paralysis. The voice

FIG. 65.—*Case* 1. Photograph to show encroachment of mouth by huge boss of left maxilla. The irregularity of the teeth is also apparent.

FIG. 66.—*Case* 1. Right profile, showing rodent ulcer and tortuous veins on scalp. The rodent ulcer has since been removed and confirmed microscopically.

is normal. The veins on the forehead (*Fig.* 66) and round the left orbit are slightly dilated; otherwise there is no evidence of circulatory obstruction due to encroachment on the canals and grooves occupied by the vessels.

The patient sleeps badly and uses hypnotic tablets. He has not, however, been able to go to the cinema for a number of years as he always falls asleep. This is suggestive of sleep inversion. There are no gross mental changes.

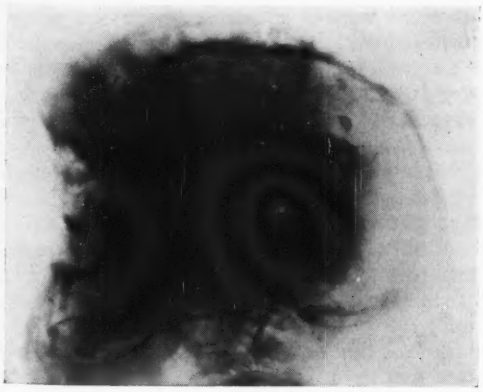

FIG. 67.—*Case* 1. Lateral radiograph of skull, showing massive overgrowth of new bone.

FIG. 68.—*Case* 1. Antero-posterior radiograph of skull.

He is intelligent, has a good memory, and is quiet and well behaved. He has never had any fits, but had a fall during a dizzy attack six months ago.

Adjacent to the external canthus of the right eye there is a rodent ulcer approximately 1 in. in diameter (*Fig.* 66). There is another on the left upper eyelid and a third on the left cheek. The dorsal spine shows a well-marked kyphosis and scoliosis, with secondary osteo-arthritis. In a number of the thoracic vertebræ the osteo-arthritic hooks from the vertebral bodies have united. A small area in the cervical region shows a certain lack of definition, but does not resemble Paget's disease. The remainder of the skeleton is normal.

The radiographs of the skull (*Figs.* 67, 68) show that considerable new bone has formed on the outer side of the parietals and from both tables in the frontal region. The original line has been completely lost in the upper part of the parietal bone posteriorly. There is a decalcified zone, but the inner table is intact.

There is no history of syphilis, and the Wassermann reaction is negative. There is no history of rickets or tuberculosis in childhood.

The blood-count shows :—

R.B.C.	5,110,000 per c.mm.
W.B.C.	12,100 per c.mm.
Hæmoglobin	102 per cent
Colour index	Unity
Neutrophil polymorphs	71 per cent
Lymphocytes	29 per cent
Serum calcium	12·3 mg. per cent
Inorganic phosphorus	2·05 mg. per cent
Phosphatase activity	8·35 units

Comment.—This patient is a veritable curio. He presents in advanced degree practically all the classical symptoms of leontiasis ossea, together with a spinal curvature with secondary osteo-arthritis of the spine, and multiple rodent ulcers, one of which was on the leg—a very rare site.

An early case of leontiasis ossea is also recorded as it presents certain interesting features.

FIG. 69.—*Case* 2. Photograph taken in 1940.

Case 2.—**Early case of leontiasis ossea limited to frontal and maxillary bones.**

The patient, D. E., a female aged 25, is married and has one healthy child, 2 years old. She is a card-room operative in a cotton mill and does heavy work. Her mother is alive and well at 52. Her father was killed in the War of 1914–18. Neither ever suffered from any bone trouble. Her medical history is good, her only illnesses having been the usual infections of childhood. (*Fig.* 69.)

She was first seen in August, 1934 (aged 19), complaining of headaches and pain in the eyes. She gave a history of having been involved in a motor cycle accident when she was 14 years old. Her head was injured and she was taken to a hospital where she was detained for a few hours and then sent home to bed for three weeks. Her recovery from the accident was apparently complete and she had no trouble until two years later when she commenced to have severe paroxysmal headaches. The headaches continued intermittently from 1931 to 1934. An attack usually lasted about two months and was followed by a free interval of approximately the same length. During the attacks she had headaches commencing at dusk each day. She had insomnia during the attacks and became very depressed. In 1934 there was no obvious deformity and no cause was found for her headaches.

She was again seen in August, 1938, and there was no change in the headaches. She was then pregnant and thought that the headaches were aggravated by her condition. By this time she had developed a definite boss over the left frontal region. An X-ray examination (*Figs.* 70, 71) showed well-marked leontiasis ossea limited to the frontal and maxillary bones. It is interesting to note how fully the left frontal bone is invaded and how the disease stops short at the suture. A considerable area of the right frontal bone is also involved, as is clearly seen in *Fig.* 71. The right maxilla is invaded to a greater extent than the left. There is no evidence of further skeletal involvement.

FIG. 70.—*Case* 2. Lateral radiograph of skull (1938) showing sharp limitation of disease to the frontal bone. Note how the suture appears to hold up the process. The maxillæ are also involved.

FIG. 71.—*Case* 2. Antero-posterior radiograph of skull (1938). Note complete involvement of the left frontal bone and extension into right frontal bone.

The patient was again seen on Dec. 6, 1940. She is again pregnant and, in contrast to her previous pregnancy, feels much better and has been much freer from headaches during this pregnancy than at any time during the last nine years. The left frontal boss has increased considerably in size and there is now an obvious boss in the right frontal bone. The involvement of the maxillæ is now easily recognized clinically by a bony ridge down either side of her nose. Both antra are opaque. There is no nasal obstruction or encroachment on the mouth, and mastication is normal. She complains, however, of very frequent colds with nasal discharge. The left eyebrow is lower than the right, and the increase in the supra-orbital ridges (particularly on the left side) causes a bulging forward of the upper eyelids. The eyes appear to be widely separated, but are otherwise normal. There are no ear symptoms or evidence of pressure on vessels or nerves.

She is 5 ft. 2½ in. in height and normally weighs 8 st. 2 lb. She is not obese, and does not show any of the symptoms of the Stewart-Morel syndrome. She does not think that her head has increased much in size. She has ceased to wear a hat as this seemed to aggravate her headaches. Philip's case,[8] a man, found similar relief followed the discarding of his hat. She has never had any symptoms suggestive of intracranial involvement and her mentality has not altered. There is no history of syphilis but her Wassermann reaction is strongly positive, with standard fixation in 1–32 dilution. There is no history of rickets or tuberculosis in childhood.

The blood-count shows a moderate degree of secondary anæmia.

R.B.C.	4,100,000 per c.mm.
W.B.C.	10,600 per c.mm.
Hæmoglobin	60 per cent
Colour index	0·75
Neutrophil polymorphs	74 per cent
Lymphocytes	24 per cent
Monocytes	2 per cent
Serum calcium	10·1 mg. per cent
Inorganic phosphorus	2·11 mg. per cent
Phosphatase activity	5·77 units

The radiographs taken in December, 1940 (*Figs.* 72, 73) show that some further involvement of the right parietal bone has taken place since 1938.

FIG. 72.—*Case* 2. Lateral radiograph of skull (1940). The condition is very similar to that in 1938, but there is slightly more involvement of the left praietal bone.

FIG. 73.—*Case* 2. Antero-posterior radiograph of skull (1940). There is further involvement of the right frontal bone.

Comment.—This case appears to be progressing very slowly. This, along with the fact that the phosphatase activity is only a little above normal and that the patient has recently been free from headaches, makes one hopeful that the disease will never reach the extreme stage of *Case* 1. It is interesting to note that the X-ray changes were consistently in advance of the physical signs.

DISCUSSION

Aetiology.—The aetiology of leontiasis ossea is still obscure. There is some doubt as to whether it exists as a distinct pathological entity. Lawford Knaggs[6] holds that all the cases which he classifies as diffuse osteitis of the bones of the face and skull are actually examples of osteitis fibrosa affecting these bones. Iviney[9] reports a case of leontiasis ossea in a child associated with osteitis deformans and osteitis fibrosa cystica, and suggested it was a case of juvenile Paget's disease. In 1902 Prince[10] expressed the opinion that leontiasis ossea and Paget's osteitis deformans were expressions of the same disease. This view has become popular, particularly in America, and is accepted without question by Boyd.[11] Paget[12] himself held that the facial bones were never involved in osteitis deformans. Recent investigations suggest that the face is actually involved in 8–9 per cent of the established cases of osteitis deformans (Geschicker and Copeland[13]; Eden[14]). Cases of Paget's disease affecting the facial bones and skull have been described by Finkelstein[15] and Thoma.[16] Hamburger and Nachlas[17] have attempted to show that leontiasis ossea is actually Paget's disease; their findings are not very convincing. The evidence against leontiasis ossea being a manifestation of Paget's disease is very heavy. The most striking disparity in ages alone makes the association very improbable. The vast majority of cases of leontiasis ossea commence before the age of 30—many in childhood. *Case* 1 had definite symptoms from 8 years of age and *Case* 2 from 19 years. Osteitis deformans is rare before middle life. The changes in the skull are never of the same degree in Paget's disease as

in *Case* 1, nor are they so irregularly distributed. The radiograph of *Case* 2 is quite unlike any stage of Paget's disease. On the other hand, the blood-phosphatase in *Case* 1 was double the normal and somewhat raised in *Case* 2, findings in keeping with Paget's disease, but also, according to Franseen, Simmons, and McLean,[18] present in most bone tumours. In Stack's case, the patient at the time of her death had a firm fibrosarcoma of the palate. This is rather in favour of the theory that leontiasis ossea and Paget's disease are manifestations of the same process. The relationship to Paget's disease is well summed up by Ruppe[19] who reported a case of leontiasis ossea with involvement of the upper two cervical vertebræ—" but as the hypertrophic bone itself and its distribution, involving as it does several bones simultaneously, does not readily fit into the category of any of our better known diseases, it would seem better, at least for the present, to consider leontiasis ossea as a disease entity, or perhaps a form of melorrheostosis ". Schwartz[20] rejects the evidence of a close relationship between leontiasis ossea and Paget's disease.

Many speculations as to the role of the endocrines in the production of leontiasis ossea have been made. No relation to the parathyroids has been established and the cases which have come to autopsy have always shown normal parathyroids. Mortimer[21] has suggested that there may be some connexion with the anterior pituitary and he has produced sclerosis of the calvarium in rats by giving the ketogenic factor of the anterior lobe of the pituitary gland.

Lawford Knaggs,[6] on not altogether convincing evidence, suggests that his cases of creeping periostitis are due to a micro-organism of low virulence, possibly a staphylococcus. In favour of this he points out that these cases practically always commence in the region of the nasal fossæ or sinuses, particularly the maxillary antrum. On the other hand, suppuration or necrosis is an extreme rarity. Surely this weighs heavily against a bacterial infection of bone? His cases of diffuse osteitis he attributes to toxin, blood-borne or locally produced. Fairbank[22] dismisses leontiasis ossea as nothing more than diffuse fibrosis. Eden[14] includes these cases among the fibro-osseous tumours of the skull and facial bones under the general term of diffuse osteomas. He regards them as true benign tumours, but admits the possibility of infection and trauma acting as irritative factors to initiate the process. The characteristic changes are the replacement of the bone-marrow by fibrous tissue, and, later, excessive formation of new bone in this fibrous tissue. This seems the most reasonable explanation of these cases. The only reference to malignant changes occurring in these cases is that of Stack's case mentioned above. Local recurrence is frequent after operation, as would be expected from the diffuse nature of the disease.

No reference to coincidental malignant disease corresponding to the multiple rodent ulcers of *Case* 1 has been found. It may be recalled that of Paget's original eight cases of osteitis deformans, five developed malignant disease,[23] at least two of which were carcinomas. Since that time the association of Paget's disease with malignancy has been well established, but only with osteogenic sarcoma.

Moore[24] gave the name of hyperostosis frontalis interna to cases of leontiasis ossea limited to the inner plate of the frontal bone. Since Morel's paper[25] in 1930 neurologists have shown considerable interest in the condition and its associated symptoms. These cases are probably true examples of leontiasis ossea, and *Case* 2 shows an intermediate condition with the disease limited to the frontal and maxillary bones. Lehoczky and Orban[26] have published a case of hyperostosis frontalis

interna with associated obesity of the rhizomelic type, intractable headaches, inverted sleep rhythm, and psychological disturbances, and have suggested the name ' Stewart-Morel syndrome '. These cases are nearly always in middle-aged or elderly women and contrast with the usual early onset of classical leontiasis ossea.

Most text-books mention syphilis as a possible factor, but the majority of cases appear to have a negative Wassermann. *Case* 2 has a positive Wassermann reaction but no history of syphilis. [The W.R. has been confirmed six months after confinement to exclude a pseudo-positive of pregnancy.] There are no stigmata of congenital syphilis. The teeth are good and quite normal. It may be noted that both these cases show wide separation of the eyes, resembling the facies of congenital syphilis.

Trauma seems to have a definite part in many cases. Schwartz[20] expresses the opinion that osteomas seem to increase in rate of growth following an injury. In both cases there was a definite history of severe injury.

Diagnosis.—The diagnosis is easy in advanced cases. In early cases headache may be the only symptom, as in *Case* 2. In the absence of a radiograph the cause is likely to be missed, and the patient to be treated as a migraine, particularly if vomiting is associated with the attacks. Epilepsy may be the first symptom if intracranial projections are present. It is important to realize that a certain number of meningiomas are associated with hyperostosis—the ' iceberg tumours ' of Rowbottom.[27] Acromegaly should present no difficulty, as the hands and feet are never enlarged. Osteitis deformans is the condition most difficult to differentiate, and in some cases this may be almost impossible. In Paget's disease the skull is likely to be more involved than the face, whereas in leontiasis ossea the reverse holds. This results in a very different shape of head. In Paget's disease the face is a triangle with the base above ; in leontiasis ossea the face is an irregular quadrilateral.

Symptoms and Clinical Course.—The disease usually begins insidiously, often in late childhood or adolescence. The skull gradually increases in size and there is usually one or more areas of localized increase—particularly in the frontal region, giving the appearance of bulging of the forehead. Headaches usually commence at an early stage in the disease—sometimes before the deformity is noticed, as in *Case* 2. The headaches are usually paroxysmal, but may be constant. Nasal obstruction and interference with chewing are usually early symptoms and may be serious. Eye symptoms are dangerous ; there may be exophthalmos, proptosis, epiphora, and optic atrophy. In extreme cases, such as Howship's,[28] the eye may be so exposed that corneal ulcer and traumatic rupture of the globe occur. Pressure on the nerves emerging from the skull may result in neuralgia or facial paralysis. Interference with the circulation may similarly arise, and dilated superficial veins may be present, indicating a collateral circulation. Stenosis of the carotid artery is said to give rise to a rushing sound in the ear, which can be temporarily controlled by pressure over the artery. Insomnia is usually present. There is sometimes an inverted sleep rhythm suggestive of pituitary trouble. No other pituitary symptoms have been recorded. These patients are said to be apathetic, but this is probably in part due to the fact that facial expression is practically lost in advanced cases. *Case* 1, although intelligent, was scarcely able to register any emotion on his face because of its immobility. The cause was clearly mechanical, not mental. Convulsions are usually a late phase, and paralysis of the limbs has been seen in the terminal stages. It is interesting to note that *Case* 1

had obviously signs of intracranial trouble in 1923, yet has been able to live a fairly normal life for another seventeen years. The condition is progressive and is said to be fatal in twenty to thirty years. *Case* 1 has a history of 46 years. Some cases become arrested without attaining the gross deformity of advanced cases. Cumston[29] has observed a series of osteomas of the skull over long periods—up to 42 years.

Treatment.—The aetiology being obscure, there is no rational treatment. Antisyphilitic treatment has been recommended, but apparently with little success. There is no evidence that X rays have any beneficial effect. Surgical treatment should be conservative for two reasons: (*a*) there is no tendency to malignancy; and (*b*) scars do not heal well. Operation has frequently been undertaken for pressure symptoms, particularly for nasal obstruction (Bland Sutton[30] operated successfully in 1888 for severe nasal obstruction); for pressure on the orbit; and for epilepsy from enostoses. Cushing[31] has advised an intracranial approach to the deep-seated hyperostoses pressing on the optic nerve by turning down a frontal osteoplastic flap.

In the great majority of cases no treatment—medical or surgical—is beneficial.

I have pleasure in acknowledging the help and criticism I have received from Mr. P. G. McEvedy and Dr. A. Dunlevy. I would also express my gratitude to Dr. A. Richardson for the X-ray plates and to Dr. R. Mackinnon and his staff for the pathological work. I am also indebted to Dr. J. Livingston, who sent the first case to see me, and to Dr. B. Dunkerley, who brought the second case to my notice.

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A ONE-STAGE OPERATION FOR HYPOSPADIAS

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With a Foreword by

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FOREWORD

Hypospadias is a grievous deformity which must ever move us to the highest surgical endeavour. The refashioning of the urethra offers a problem as formidable as any in the wide field of our art. The fruits of success are beyond rubies—the gratitude of a boy has to be experienced to be believed.

Those of us who could not evade the responsibility of attempting to deal faithfully with these patients, received a lively encouragement from the work of Edmunds. The 'three-stage' operation, so skilfully evolved and successfully practiced by him was a notable advance for which all owe him a grateful tribute.

If, however, one could succeed in remodelling the urethra in one operation, the gain would be manifest. The operation here described is designed to achieve this. It has been my privilege to be associated with Mr. Humby in the treatment of some of these cases. The results have appeared to demand the publication of details, and to justify the hope that the wider employment of this ingenious procedure may prove that a further landmark in the treatment of hypospadias has been reached.

T. Twistington Higgins.

INTRODUCTORY

It would be difficult to find a condition less amenable to operative treatment than is hypospadias. The multiplicity of operations described for the correction of this deformity tends to show that none is wholly satisfactory. The customary three-stage operations frequently have to be extended to many more before the final result may be considered adequate.

The operation, about to be described, is a one-stage procedure suitable for any degree of hypospadias. It can be performed on a penis however badly mutilated by previous operations, and, furthermore, it does not need the presence of a prepuce for its execution. When completed, the urethra emerges from the glans tip and cannot grow hair within its lumen.

Experience has shown that it is advisable to postpone operation until the child is five or six years old. He will then tolerate more easily the suprapubic cystotomy,

which, as will be described, is essential. Also, at this age, the operation is simplified by the larger size of the penis.

In certain younger patients Pregnyl has been administered with the object of increasing the size of the penis, but the possible deleterious effects upon the cells of the testes has prohibited its further use until the contrary has been proved.

It is not suggested that the common degrees of glandular hypospadias should be submitted to this procedure, because the urethra in these cases can be so simply constructed from the adjacent non-hairy skin of the penis.

The case that is illustrated (*Fig.* 74) had been subjected to five previous operations.

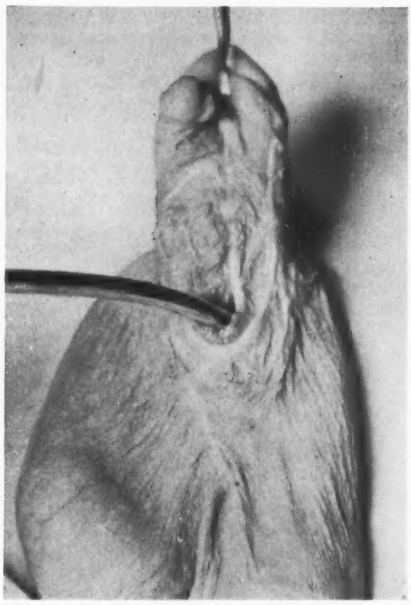


FIG. 74.—A hook has been inserted into the glans to elongate the penis.

The object of the operation is to construct a urethra by a free full-thickness tubed skin-graft: 70 per cent of full-thickness grafts take perfectly elsewhere in the body, and the 30 per cent deficit is made up in the penis by the extraordinary blood-supply. In no case, so far, has the graft failed to 'take'.

DESCRIPTION OF OPERATION

1. Suprapubic Cystotomy.—Operations for hypospadias usually fail through urine flowing past a new suture line in the penis and washing away the organizing blood-clot. Therefore, the first step in the operation consists of a stab suprapubic cystotomy with the insertion of a de Pezzer catheter. The suprapubic cystotomy is expedited by a 'grab' bougie (*Fig.* 75) which can grip the de Pezzer catheter and pull it into the bladder. The 'grab' bougie is passed into the bladder and pressed against the abdominal wall: the jaws are then opened and the skin and bladder overlying the gap between the jaws are incised. This allows the jaws to protrude through the abdominal wall: the catheter is then clamped by the jaws and pulled back into the bladder: the jaws are loosened, and the bougie removed from the bladder and urethra. No stitches are necessary in the anterior abdominal wall or the bladder.

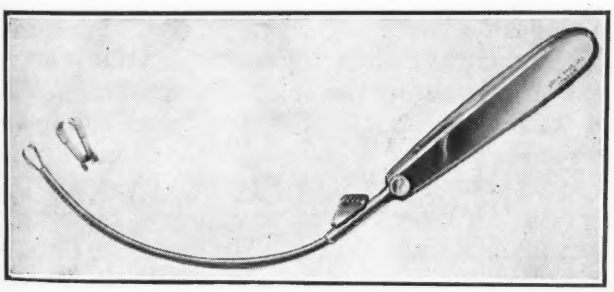
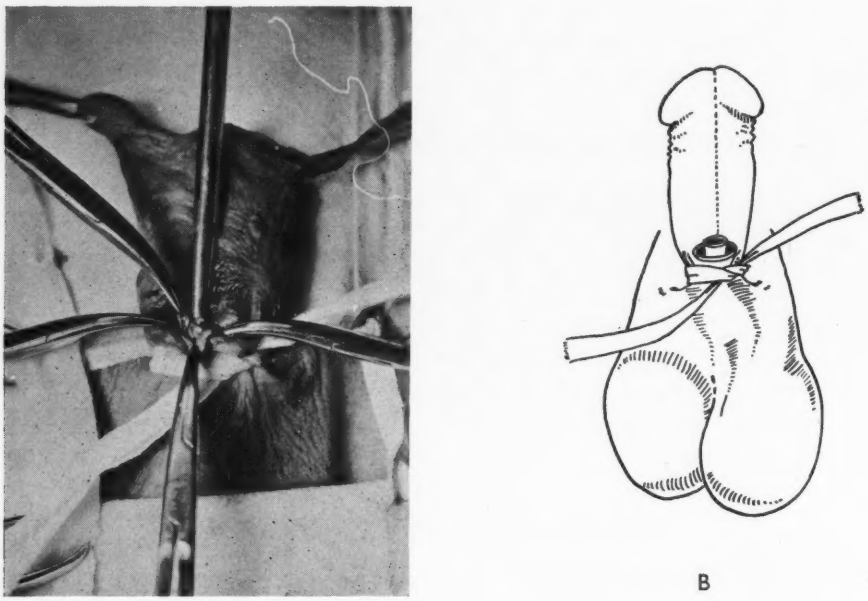


FIG. 75.—The 'grab' bougie.

The subsequent suction that is applied to the suprapubic must be a constant one such as is produced by a Sprengel's pump from a constant water-supply or

some other well-regulated automatic apparatus, because fluctuations of the negative pressure are responsible for the periodic leakage of urine through the internal sphincter of the bladder. The negative pressure in a Vacoliter varies with the amount of fluid in the container, and in consequence this type of apparatus is unsuitable for the post-operative suprapubic drainage.

2. Freeing of the Urethra.—The operation is simplified by tying a tourniquet of tape around the root of the penis (*Fig.* 76). In some cases this is not possible because the opening of the urethra is too far back in the scrotum.



A B

FIG. 76.—A, Four mosquito forceps are clipped to the freed urethra; B, The tourniquet prevents the urethra from slipping beneath the undermined scrotal skin. The dotted line shows the position of the longitudinal incision.

A metal bougie of largest calibre is inserted into the urethra, then with a Bard Parker No. 11 blade knife the urethra is freed from the scrotal skin and corpora cavernosa; this dissection is rather delicate on the ventral aspect because the urethra is only covered by skin, but if the knife is kept parallel to the bougie the freeing can be accomplished for the requisite half-inch towards the bladder. The purpose of this circular incision around the urethra is twofold: the chordee which is always present in these cases is partially caused by the adherence of the corpora cavernosa to the urethra in this situation and the freeing of the urethra is the first step in the elimination of the chordee; the other result of the dissection is that the urethra slips from view beneath the undermined skin of the scrotum and in consequence the subsequent anastomosis between the urethra and the free tubed skin-graft will be found to lie deep to the scrotal skin and not underneath a fresh suture line. This point is shown by X in *Fig.* 81.

3. Preparation of the Bed for the Urethral Graft.—The circular incision around the urethra is then extended towards the tip of the glans. This is shown

by the dotted line in *Fig.* 76, B, and through this incision the remainder of the chordee can be eliminated by excision of the atrophic corpus spongiosum, which stretches from the urethra to the corona.

After the fibrous strands of corpus spongiosum have been removed from the ventral surface of the corpora cavernosa, the penis is ' kippered ' or split longitudinally from the mobilized end of the urethra to the tip of the glans. The depth of the ' kippering ' should be at least half the diameter of the penis. (*Fig.* 77.)

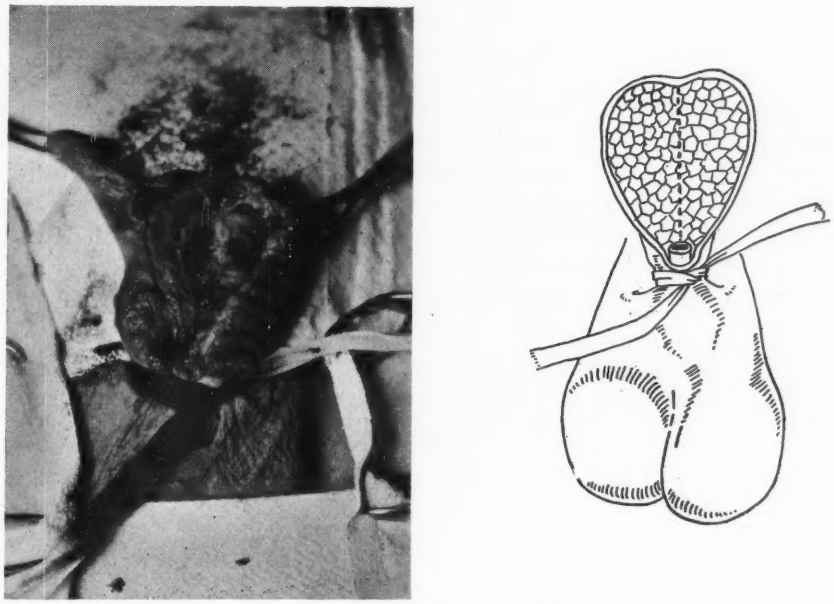


FIG. 77.—Illustrating the ' kippering ' of the penis and the hæmostasis of the corpora cavernosa, when a tourniquet can be applied.

The next step consists in undermining the penile skin on both sides of the original longitudinal incision. As one works towards the glans the ' dog ears ' of the prepuce are mobilized so that they can help to cover up the new urethra to the tip of the penis.

4. Preparation of the Urethral Graft.—A full thickness skin-graft is then taken from some non-hairy portion of the body: if the foreskin is present and large

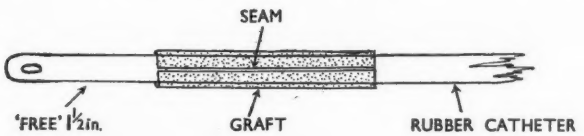


FIG. 78.—The graft glued around a rubber catheter, 1½ in. from its lower end.

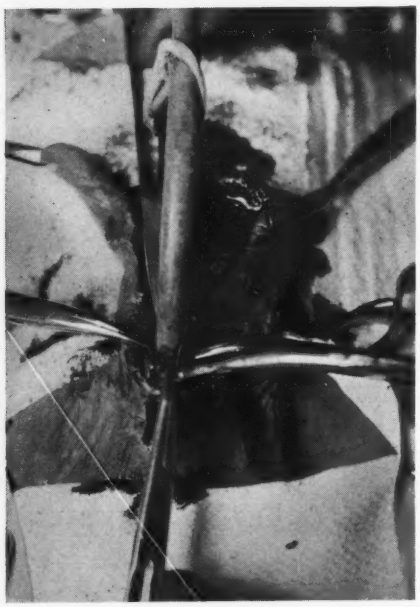
enough this may be used for the graft, but usually it is found that the graft has to be dissected away from the subcutaneous fat on the inside of the upper arm. With an ordinary knife this is a laborious process and bits of fat will be found to be adhering to the deep surface of the skin; afterwards, they in turn will have to be dissected off. A few years ago Messrs. Down Bros. made for me a graded

guarded graft-cutting knife which guarantees the required thickness of skin (*Fig.* 79). This can be thoroughly recommended for this operation as the graft need not be tampered with after its production by this instrument.

FIG 79.—Guarded graft-cutting knife.

5. Implantation of the Graft.—The distance between the opening of the urethra and the bladder is measured roughly, and we will count the distance as being, say, 2 in. The external surface of the graft is glued with benzol mastiche around a rubber catheter of the largest calibre that the urethra will admit, say $1\frac{1}{2}$ in. from its lower end (*Fig.* 78).

The tip of this catheter with its adherent graft is then inserted into the urethra (*Fig.* 80); the free $1\frac{1}{2}$ in. of the catheter is shorter than the urethra in order to



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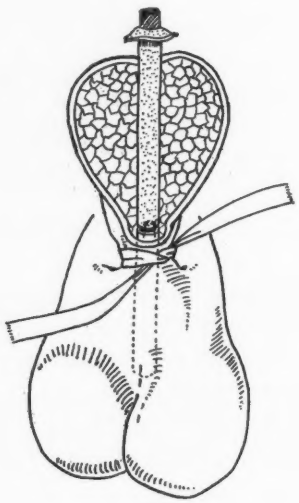
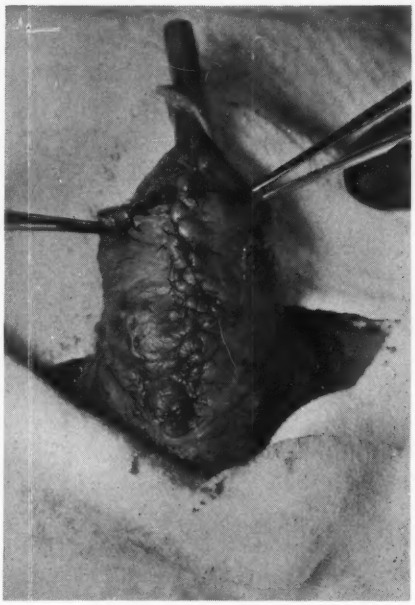


B

FIG. 80.—A, B, The tourniquet has been removed and the graft glued to the catheter; the free $1\frac{1}{2}$ in. of the catheter has been inserted into the urethra. In B two of the three interrupted silkworm sutures are shown at the anastomosis.

ensure that the catheter does not pass through the internal sphincter of the bladder—if this should inadvertently happen there would be a periodic leakage of urine through the urethra in spite of the constant suprapubic drainage. The 'seam' of the graft must face the corpora cavernosa so that it does not coincide with the skin-suture line which is described later.

6. Anastomosis between Graft and Urethra.—There is no need to suture the sides of the 'seam' of the graft together, as the benzol mastiche is sufficient



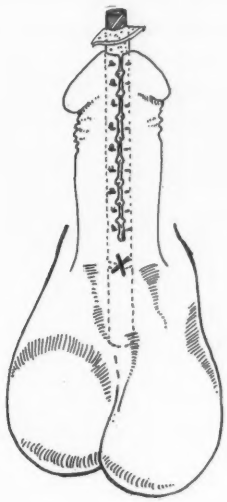


FIG. 81.—A portion of the graft is seen protruding beyond the glands.

to keep them approximated, but the anastomosis between the urethra and the graft is better sutured by two or three interrupted ophthalmic atraumatic No. 6 eye curved sutures (*Fig.* 80, B); in earlier cases of the series operated upon, 6/0 catgut was used for this purpose, but it was found unsatisfactory because it caused a reaction in the fine tissues concerned and for this reason was abandoned in favour of the fine silkworm which is readily expelled from the urethra in about ten days after operation.

7. The Burial of the Graft.—The undermined sides of the longitudinal incision are sutured to each other over the graft and catheter with ophthalmic silkworm sutures, care being taken to introduce corpora cavernosa into the deep parts of the mattress sutures in order to have some body of tissue covering the ventral surface of the graft. Especially is this important at the anastomosis; lack of this body of tissue at the junction of the urethra and the graft will tend to promote fistula formation. Finally,

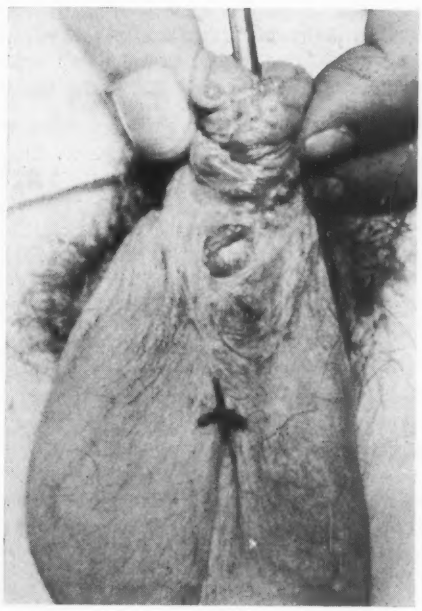


FIG. 82.—One year after operation. X marks the site of the anastomosis.

a stitch is passed through the glans and the catheter to retain the catheter during the post-operative period. (*Fig.* 81.)

The penis is dressed with ribbon gauze and bound over the pubis in the erect position, producing a dorsal curvature, thus budgeting for any subsequent longitudinal contraction of the graft. The dressing is left undisturbed for ten days, suction drainage of the bladder being maintained the whole time. At the end of this time the catheter will be found to slip easily from the urethra. All dressings and stitches are then removed and the penis and scrotum are protected by a cage. The de Pezzer catheter is removed on the fourteenth day.

The obvious criticisms of this operation will be in relation to the amount of contraction that occurs in the graft, the possible recurrence of the chordee, and the question of stricture formation at the anastomosis. The case from which these photographs were taken will help to reply to these criticisms. One year after the operation, the constructed urethra would admit the same size bougie as was used in the original operation (*Fig.* 82). Surgeons with some experience in skin-grafting will agree that it is unlikely for any further contraction to occur after this time. The boy can get normal erections without chordee and the skin moves freely over the urethra. Twelve cases have been submitted to this procedure.

CASE REPORTS

A brief survey of the first few cases in this series is interesting because it shows how the technique for this operation has been evolved.

Case 1.—Anthony, aged 6 years.

This child had been submitted to the three-stage Edmund's operation, and was admitted with a peno-scrotal hypospadias rather more severe than his original condition; he had a mobile penis, but no prepuce.

The technique already described was employed, but a Thiersch graft from the thigh was used for the urethral implant: the graft took perfectly, but the boy developed a chordee and the lumen of the urethra had contracted; it is not, however, causing him any inconvenience, and in due course it will be necessary for him to have a full-thickness graft substituted for the Thiersch graft.

Case 2.—David, aged 4 years.

An intermediate-thickness graft was used for the urethral implant. This case developed a fistula at the urethral anastomosis and it was thought to be due to catgut being used for the anastomosis and causing too much reaction in the fine tissues. The fistula had to be repaired; and in subsequent cases interrupted silkworm sutures were used instead of catgut.

There was some chordee and contraction of the urethra, but not so marked as in the previous case. This child is being watched to see how he progresses.

Case 3.—Peter, aged 8 years. (*Fig.* 83.)

This child had had many operations resulting in a peno-scrotal fistula. This was the first case in which a full-thickness graft was used. The decision for using such a graft was because the penis was very fibrosed and bound down, and it was thought that the extra fibrosis which would accompany a Thiersch graft would make erection of the penis impossible.

With some misgivings, mucous membrane from the lower lip was taken for the implant. On the sixth day after operation the skin-suture line broke down, so the de Pezzer catheter was removed and the case regarded as a failure: but later it was proved that the graft had taken perfectly in the same way as an epithelial inlay for ectropion of the eyelid, and all that was needed was a simple suture over a penile catheter. The boy has now a perfect penis.

There were two possible reasons for the breakdown: one was the questionable aseptic character of a mucous membrane graft; but as the graft had taken perfectly everywhere except at the skin-suture line, it is unlikely that this was the prime factor for the breakdown.

The second, and more probable reason, was that in these first three cases all that covered the ventral aspect of the graft was penile skin: in the first two cases this was enough to supply the thin grafts with the nourishment that they required, but in this case the full-thickness graft needed more sustenance than the fibrosed skin could supply. This complication has not recurred, because in all subsequent operations care has been taken to introduce corpora cavernosa into the deeper parts of the mattress sutures over the ventral surface of the urethral implant; this manœuvre was assisted by making deeper the 'kippering' of the penis.

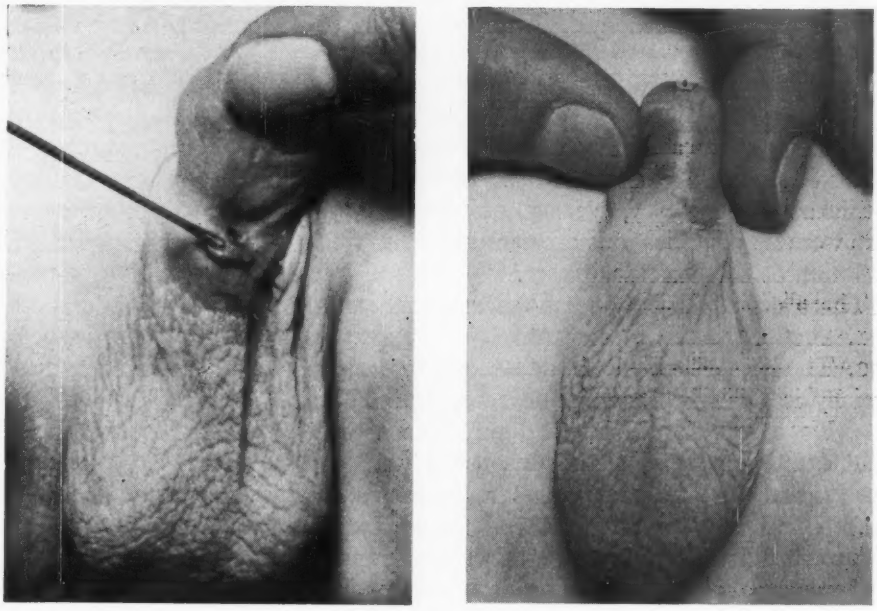


FIG. 83.—*Case* 3. The prepuce in this case was reconstructed so perfectly that, as can be seen, the child may need circumcising in the future.

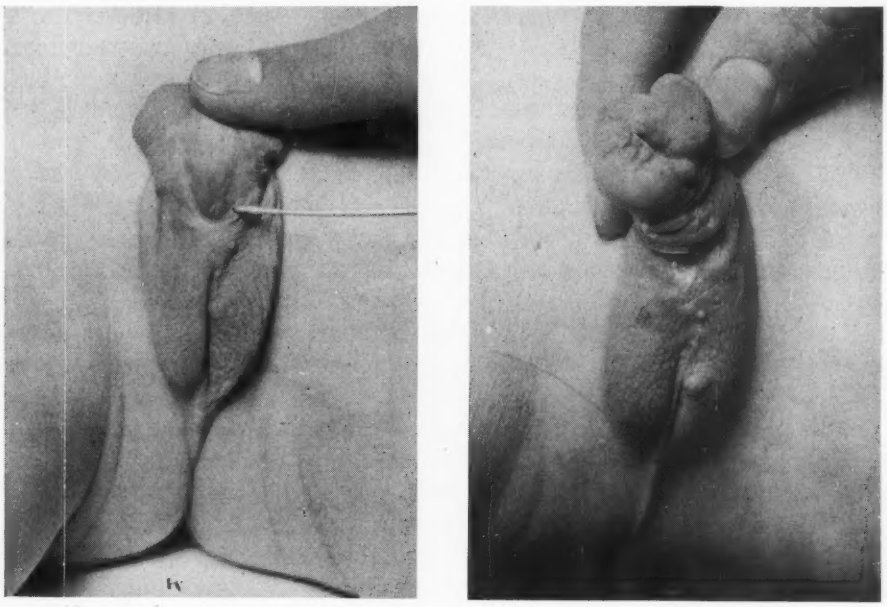


FIG. 84.—*Case* 4. The corona is shown still œdematous after removal of the prepuce for the graft.

Case 4.—John, aged 5 years. Peno-scrotal hypospadias (upon which a first stage Edmund's had been done). (*Fig.* 84.)

As the prepuce was present more or less intact, this was used for the tube graft. The result was perfectly successful. There is no reason why this should not always be used for the implant, but in practice it is often found to be missing owing to over-zealous circumcision or previous unsuccessful operations.

Case 5.—Bobby, aged 6 years.

This case demonstrates how little a full-thickness tube graft contracts. A stitch abscess at the anastomosis occurred on the fourth day and the boy was sent home for four months, during which time he passed all his urine through the fistula. On re-admission to hospital the constructed urethra through which no urine had passed admitted a bougie the same size as the rubber catheter which had been used at the original operation.

The last 7 cases of the series followed exactly the routine treatment already described: they were all scrotal or peno-scrotal degrees of hypospadias and the full-thickness implants were usually taken from the inside of the right upper arm. There were no complications of special note, so there is nothing to be gained from a description of the individual cases.

Three points in the operation cannot be too strongly emphasized:—

1. Suction must be constant.

2. The implant must be buried deeply in the substance of the corpora cavernosa; especially is this important at the anastomosis.

3. No catgut should be used throughout the operation.

The first operation along these lines was performed two years ago, so it is impossible to state whether the graft grows with the penis, or whether it will be stretched with subsequent penile erections: but, even if it does not grow at all, the constructed urethra is large enough to perform adult functions. The results so far suggest that the graft does grow with the penis, but time alone can answer this question.

ISCHIOFEMORAL ARTHRODESIS

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ARTHRODESIS of the hip is performed for tuberculosis, osteo-arthritis, and infective arthritis. No one method of fusion can be constantly employed in these different diseases, nor in different stages of the same disease. The two operations most usually performed are an *extra-articular iliofemoral arthrodesis*, either an iliac or a tibial graft being used, and a *combined extra- and intra-articular operation*, where in addition to the above the hip-joint is opened and the joint surfaces denuded of cartilage. Various modifications of these operations are also advocated.

Certain essentials are necessary for the success of the extra-articular iliofemoral arthrodesis :—

1. *In tuberculosis the limit of bone destruction must be reached.* Otherwise progressive disease will cause too great a strain on the graft, which will fracture or become separated at either end. The disease may also actually extend into the ilium and attack the upper end of the graft.

2. *The hip must not be dislocated.* The presence of a pathological dislocation with the head of the femur riding up on the ilium renders iliofemoral arthrodesis difficult or impossible. In old congenital dislocations of the hip with arthritic changes, an iliofemoral arthrodesis cannot easily be performed.

3. *The patient's general condition must be good.* Tibial grafts, particularly in children with tuberculous hips, frequently fail to fuse if the child is not healthy. In osteo-arthritis new-bone formation is diminished, and an extra-articular graft alone may not be sufficient to fix the joint.

The combined operation gives a better chance of fusion, but it has certain disadvantages :—

1. *It is a formidable procedure*, both in tuberculosis and osteo-arthritis. The forcible dislocation of the hip at operation is apt to cause shock.

2. As in the extra-articular operation, in tuberculosis *the limit of bone destruction should have been reached.* If there is no evidence of local resistance to disease, as shown by a line of sclerosis in the radiograph, removal of macroscopical disease may leave an area of microscopical disease which will progress even after the operation. The surgeon may, in fact, remove the powers of resistance which are limiting the spread of disease.

3. In osteo-arthritis, reduction of the size of the head and increase in the capacity of the acetabulum through the removal of the articular cartilages make complete and *adequate apposition of bony surfaces impossible.*

Ischiofemoral arthrodesis is an alternative method of operation which has afforded a high percentage of fusions in the series here recorded, and can be offered to any patient below the age of 65, provided that in tuberculosis the rare complication of disease extending downwards into the ischium is absent. By ischiofemoral arthrodesis is meant arthrodesis of the hip by means of fusion between the ischium and the shaft of the femur in the region of the small trochanter.

The operation consists of performing a subtrochanteric osteotomy at a previously selected site, passing the osteotome into the ischium in the same line for a distance of one inch, and introducing a massive flat tibial bone-graft consisting of the entire medial surface of the tibia. One end of the graft then lies well implanted in the ischium, and the other lies between the two fragments of the osteotomy. The limb is then abducted so that the lower fragment comes into contact with the ischium, and the graft is thus supported throughout its entire length. (*Fig.* 85.)

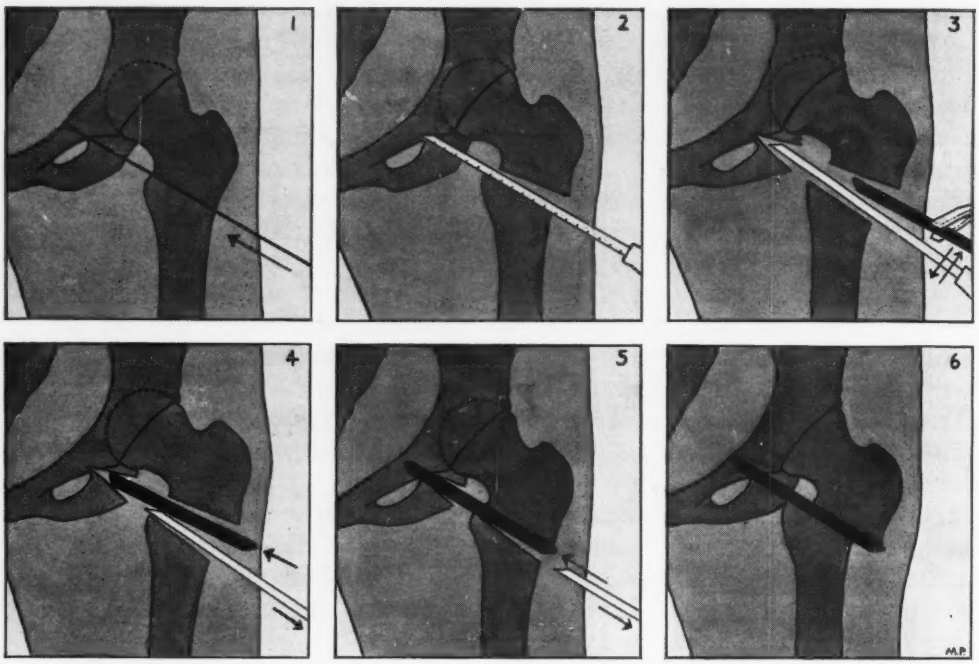

FIG. 85.—Ischiofemoral arthrodesis. 1, The line of osteotomy continued through into the ischium, passing just above the obturator foramen. 2, Osteotomy performed. The chisel is passing into the ischium for a distance of 2 cm. An X-ray photograph should be taken here. 3, The chisel has been rocked up and down to widen the aperture in the ischium. The graft is about to be introduced above the chisel. 4, The graft is introduced into the aperture while the chisel is being withdrawn. 5, The graft is well embedded in the ischium, and the chisel has been completely withdrawn. 6, The graft has been further impacted into the ischium and the shaft of the femur has been pushed in underneath the graft to support it.

Ischiofemoral arthrodesis has very definite advantages over the iliofemoral operation. One possible disadvantage is common to both—namely, that the disease may involve the graft. Tuberculous disease, however, much more frequently extends upwards into the ilium than downwards into the ischium, in fact the latter is extremely rare. The operation has another disadvantage—namely, that it is performed blindly. This is a theoretical disadvantage which in practice and under X-ray control presents few difficulties. The possibility of passing the chisel or graft into the pelvic vessels or injuring the sciatic nerve has been visualized, but actually none of these structures has been encountered. In patients operated on there have been no fatalities, and in only two patients has there been any post-operative shock. Also, the percentage of fusions is at least as good as in other recorded series.

TECHNIQUE OF OPERATION

The patient lies on his back, and one Michel clip is placed on the skin of the groin just below the head of the femur. An antero-posterior radiograph is taken, and the clip then serves as a guide for the direction of the graft, which is cut from the tibia of the unaffected limb. A graft 4–5 in. in length is usually sufficient. It consists of the entire medial surface of the tibia and the anterior and medial crests. An incision 7 in. long is made over the middle of the skin of the subcutaneous surface of the tibia. The periosteum is removed from the entire tibia throughout the length of the incision. Two bone elevators are passed subperiostially beneath the medial margin of the tibia, and slid towards the distal ends of the wound. A bone-graft 5 in. long is cut to include both the anterior and medial crests of the tibia. It is therefore cut through the lateral and posterior surfaces, and these are joined across the medial surface at each end (*Fig.* 86). The

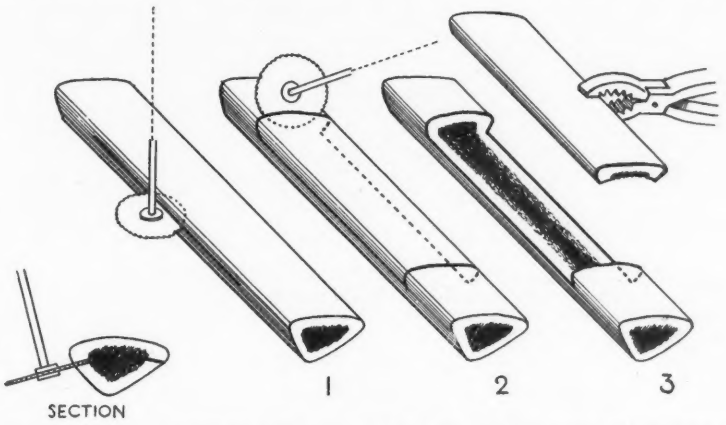

FIG. 86.—Method of cutting the tibial graft. The graft includes the entire medial surface of the tibia and both the antero-lateral and postero-medial borders. It is 5 in. long.

wound is closed in the usual way, except that it is easier than usual to sew the periosteum together, as the width of the tibia has been decreased.

A subtrochanteric osteotomy is now performed at a previously selected site at an angle of 45°. The osteotome is then passed inwards along the under surface of the neck of the femur until it impacts against the ischium. It is kept in the coronal plane, which is easily ascertained by putting one's hand on both anterior superior iliac spines. A graduated chisel is now introduced between the fragments until it abuts against the ischium, and is firmly driven into the ischium for a distance of about one inch. The chisel is driven in in the same line as the osteotomy, namely, at 45°, in the sagittal plane and in the coronal plane of the body. When it has been driven in for a distance of 1 in.—and this can be seen by the graduations on the chisel—an X-ray photograph is taken of the level of the chisel, and its distance in the ischium is confirmed. It should be hammered in until it just reaches to the brim of the pelvis. It is then rocked upwards and downwards over a dozen times until a fair-sized aperture has been made. The graft is now introduced over the upper surface of the chisel, its raw surface facing downwards. It should just fit into the opening in the ischium (*Fig.* 87). It is then punched into the aperture, while the chisel is gently withdrawn. After it has been introduced

for a distance of 1 in. it should be hammered in very firmly for a further ½ in. until it is gripped by the ischium. Its outer end should lie between the divided fragments of the femur. Any redundant part of the graft should, of course, be removed. The limb is now abducted until the upper end of the lower fragment abuts against the ischium, and is held by an assistant while the muscles are sutured. A double

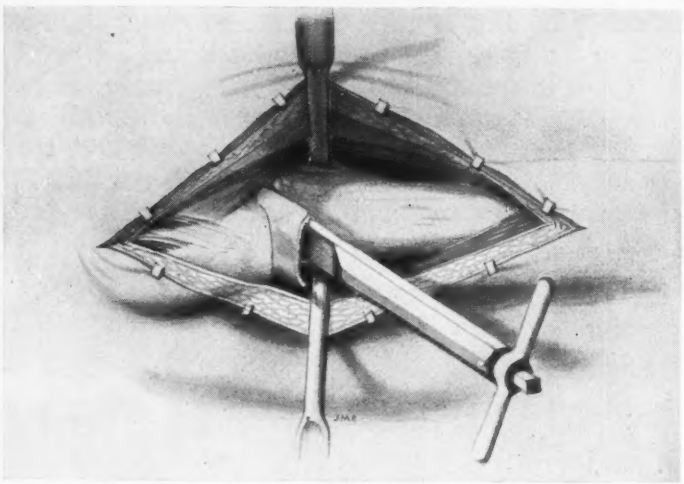

FIG. 87.—Ischiofemoral arthrodesis. The tibial graft has been introduced above the chisel into the ischium. The chisel is about to be withdrawn.

plaster spica is applied, the affected limb being put in plaster first, so that the contact of the lower fragment with the ischium may be maintained without subjecting the knee to a valgus strain. For efficiency in nursing both hips are included with a cross-bar. After eight weeks the plaster on the unaffected hip is removed.

Fusion usually takes place in from four to six months, and in osteo-arthritis the time will probably be shorter, but in tubercle, of course, it may be necessary to immobilize the patient for considerably longer until the disease has healed.

RESULTS

It will be seen from *Table I* that the percentage of bony fusions following the first operation is 80 per cent. Although the hip has clinically fused in some of these patients, the disease has not yet healed, and they are still being kept at rest. In three patients the operation had to be repeated, in one patient repeated twice. These patients bring the percentage of fusions to 88 per cent.

Should fusion not occur through the graft being passed too high into the area of disease, the operation can easily be repeated. This is a simple matter, as landmarks can easily be found by exposing the great trochanter, and a second graft can be passed in immediately below and parallel to the first. In the patient who was operated on three times, at the first operation the graft did not pass in far enough, and at the second the graft was passed above the first graft instead of below, with the result that it became invaded by disease. The third fused well. This patient had already had many years of conservative treatment, and the disease had extended high up in the ilium, prohibiting iliofemoral arthrodesis. (*Figs.* 88–93.)

Table I.—SUMMARY OF RESULTS OF ISCHIOFEMORAL ARTHRODESIS

CASE NO.	AGE	DISEASE	LENGTH OF HISTORY	OPERATION	PRESENT CONDITION
1, V. H.	17	Tuberculosis of hip	8 yr.	Feb. 20, 1936	Fused
2, P. R.	15	Ditto	1 yr. 8 mth.	July 15, 1937	Fused
3, E. D.	32	Ditto	6 yr.	Aug. 8, 1937	Fused
4, V. C.	14	Ditto	3 yr.	Oct. 2, 1937	Fused
5, C. S.	63	Osteo-arthritis	—	May 20, 1938	Fused
6, M. R.	57	Ditto	—	June 1, 1938	Fused
6, G. L.	17	Tuberculosis of hip	6 yr.	June 20, 1938	Fused
8, E. W.	56	Osteo-arthritis secondary to congenital dislocation of hip	—	Nov. 11, 1938	Not fused, but no complaints
9, F. P.	56	Osteo-arthritis	—	Nov. 16, 1938	Fused
10, D. T.	22	Tuberculosis of hip	4 yr.	Nov. 20, 1938	Fused
11, D. M.	48	Infective arthritis	—	Dec. 2, 1938	Fused
12, J. J.	54	Osteo-arthritis	—	Dec. 11, 1938	Fused
13, A. D.	28	Infective arthritis	2 yr.	Dec. 18, 1938	Fused
14, A. B.	36	Tuberculosis of hip	24 yr. intermittent	April 21, 1939	Fused. Fibrous union between trochanter and shaft. No complaints
15, N. C.	15	Ditto	9 yr.	June 29, 1939	Fused
16, A. S.	62	Osteo-arthritis	—	July 21, 1939	Not fused, but no complaints
17, I. C.	28	Osteo-arthritis secondary to congenital dislocation of hip	—	July 31, 1939	Fused
18, E. R.	62	Osteo-arthritis	—	Aug. 20, 1939	Fused
19, J. L.	16	Tuberculosis of hip	10 yr.	Aug. 22, 1939	Fused
20, R. B.	9	Ditto	2 yr.	Sept. 7, 1939	Fused. Disease still active
21, M. C.	10	Ditto	1 yr. 8 mth.	Sept. 21, 1939	Fused
22, D. B.	9	Ditto	4 yr.	Oct. 5, 1939	Not fused. Disease involving graft
23, B. B.	18	Ditto	11 yr.	Oct. 25, 1939	Not fused. Disease involving graft
24, F. B.	16	Ditto	4 yr.	Oct. 27, 1939	Fused. Two operations
25, M. M.	41	Ditto	34 yr. intermittent	Nov. 8, 1939	Fused
26, M. G.	58	Osteo-arthritis	—	Nov. 24, 1939	Fused
27, S. G.	16	Tuberculosis of hip	10 yr.	Dec. 4, 1939	Fused
28, C. N.	58	Osteo-arthritis	—	April 10, 1940	Fused
29, P. B.	9	Tuberculosis of hip	5 yr.	April 18, 1940	Fused. Three operations
30, R. S.	61	Osteo-arthritis secondary to congenital dislocation of hip	—	April 21, 1940	Fused
31, F. B.	10	Tuberculosis of hip	7 yr.	April 25, 1940	Fused
32, J. B.	11	Ditto	4 yr.	April 27, 1940	Fused
33, T. C.	19	Infective arthritis	—	May 10, 1940	Fused. Two operations
34, P. M.	17	Osteo-arthritis secondary to congenital dislocation of hip	—	May 17, 1940	Fused
35, N. J.	58	Infective arthritis	—	June 5, 1940	Fused

One patient aged 58 with osteo-arthritis died eight days after operation from a pulmonary embolus confirmed by post-mortem examination.

FIG. 88.—*Case* 10. Tuberculous hip. Iliofemoral arthrodesis failed. Fracture of graft owing to too great a strain. Operation probably performed before limit of bone destruction had been reached.

FIG. 89.—Same case. Successful ischiofemoral arthrodesis.

FIG. 90.—*Case* 19. Tuberculous hip. Ten years' treatment. Operated on at active stage.

FIG. 91.—Same case. Successful ischiofemoral arthrodesis. Note displacement of shaft of femur to support graft underneath.

SUGGESTED ADVANTAGES OF OPERATION

The following remarks apply almost entirely to tuberculous disease.

1. Architectural.—It is a basic architectural principle that compression is to be preferred to tension unless adequate material, that is material strong enough to stand up to tension, is used. A bone-graft is the strongest material that can

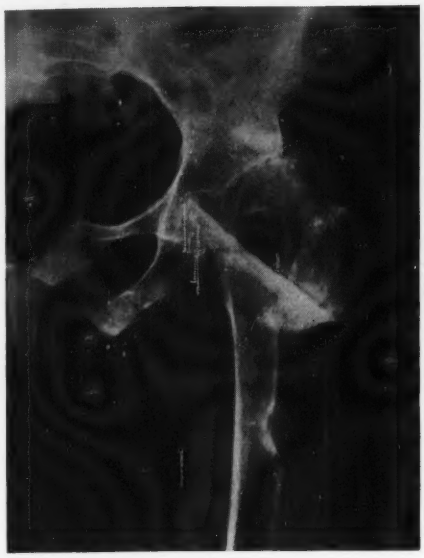

FIG. 92.—*Case* 6. Osteo-arthritis of hip. Graft taken from shaft of femur. Note apparent fusion between head of femur and acetabulum.

FIG. 93.—*Case* 17. Old congenital dislocation of the hip with arthritis. Successful ischiofemoral arthrodesis. Union at osteotomy site was slow.

safely be used for this procedure, and a graft should not be subjected to more strain than is necessary.

There can be little doubt that the underlying strut passing from the femur to the ischium on the adductor aspect of the hip, as first suggested by Calvé and later put into practice by Trumble, is mechanically sounder than the flying buttress type of graft from the ilium to the great trochanter. The strut is subjected to a compression stress on its long axis, while the iliac graft is subjected to a tensile force. Furthermore, the latter force is not only acting on the graft itself, but is tending to disrupt each point of attachment of the iliofemoral graft, whereas compression is constantly tending to make both attachments of the ischiofemoral graft more secure. Even in plaster-of-Paris there is a tendency for the hip-joint to adduct. There are so many soft parts on the inner side of the thigh, and wasting undoubtedly takes place. In *Figs.* 94–97 it can be clearly seen that adduction has taken place. This, of course, may put a tensile strain on the iliofemoral graft, which may cause failure of fusion, while it will only tend to make the ischiofemoral graft more secure.

2. Anatomical Approach.—Trumble's operation is difficult, and the ischium is anatomically difficult of access. In front are the femoral vessels; behind, the sciatic nerve is directly in the way; on the inner side of the thigh are numerous structures—the adductor muscles, the obturator nerve, the arteries, and the femoral vein. But the ischium can be reached easily, if blindly, through an osteotomy of the femur, and if one keeps in the coronal plane the important anatomical structures are avoided.

During the early cases in this series, one had anxiety lest the graft should pass through the obturator foramen. It has been found, however, that this bogy is not justified, as a graft 1 in. wide cannot actually pass through the foramen if it starts from the osteotomy site, as the foramen is so obliquely placed.

FIG. 94.—*Case* 24. Tuberculous hip. Five years' conservative treatment. Note large abscess in ilium.

FIG. 95.—Same case. Ischiofemoral arthrodesis. Radiograph taken immediately after operation. Shaft of femur not sufficiently displaced inwards.

On several occasions grafts have been passed parallel with the foramen almost into the symphysis pubis.

FIG. 96.—Same case, 5 months later. Successful ischiofemoral arthrodesis. Note that the shaft has actually travelled inwards in plaster, due to adduction pull. Note gradual disappearance of abscess in ilium.

3. Bony Fusions.—It is most unusual for a subtrochanteric osteotomy to fail to unite. One end of the bone-graft is placed between the fragments and becomes involved in the bony union. The other end is placed in an environment very favourable for union—namely, it is well buried in cancellous bone, and there are five bony surfaces in apposition. It appears from observation that union usually takes place last between the upper surface of the graft and the lower surface of the great trochanter. Care must be taken not to pass the graft too high into the area of disease. Of great importance, also, is the contact of the lower fragment with the ischium, as this appears to stabilize the graft, and is a support underneath what would otherwise be a gap.

4. The Advantages of being Extra-articular.—The advantages of a pure extra-articular fusion are only of importance in tuberculous and possibly infective arthritis. The extra-articular iliofemoral arthrodesis is usually difficult and may be impossible in tuberculous disease, because there is no certainty that the disease has not advanced far beyond the limits revealed in the radiograph. Further, an abscess may be

opened at an early stage of the operation which may delay healing and cause post-operative sinuses. This occurred in several of Henderson's cases, though

FIG. 97.—Contrast between *Case* 24 and extra-articular method. Adduction has occurred in each, causing fibrous union between the graft and the great trochanter in one patient, but helping fusion in the other.

not in Seddon's or Barr's. It is common, also, for tuberculous disease to spread so extensively in the upper part of the acetabulum and adjoining ilium as to render iliofemoral arthrodesis inadvisable or impossible. It is, however, rare for disease to spread in the lower part of the acetabulum

FIG. 98.—*Case* 20. Ischiofemoral arthrodesis 4 months after operation. Graft passed farther into pelvis than usual. No symptoms caused. Note new bone at inner end.

FIG. 99.—Occasionally it may be difficult to establish by radiography with certainty that there is union between the graft and the shaft of the femur. The lateral view will always determine this as above.

and extend into the ischium. It has been found possible in this series, with two exceptions, to perform an ischiofemoral arthrodesis below the level of the disease. An attempt is made to cure the disease by short-circuiting rather than by 'encirclement'. (*Figs.* 98, 99.)

FIG. 100.—*Case* 7. Tuberculous hip, 8 years' history.

FIG. 101.—Same case, 3 years after operation. Note absorption of graft and re-trabeculation.

FIG. 102.—*Case* 27. Tuberculous hip, 11 years' history.

FIG. 103.—Same case, 6 months after operation. Note new bone at each end of graft. Graft has passed into the pubis.

5. Pseudoarthroses with Smouldering Disease.—The treatment of these patients has always been a problem. Iliofemoral arthrodesis is not possible, and conservative treatment cannot cure them sufficiently to allow them to take weight

without the probability of a recrudescence. Bankart's complete excision is a formidable procedure for most surgeons, and children do not tolerate it well. Ischiofemoral arthrodesis, however, offers them a chance of a stable hip because of the weight transference (*Figs.* 100–103).

FIG. 104.—*Case* 21. Tuberculous hip after 16 months of conservative treatment. Obviously far from quiescent.

FIG. 105.—Same case. Ischiofemoral arthrodesis. Radiograph taken on operation table.

FIG. 106.—Same case, 5 months later. Successful ischiofemoral arthrodesis. Note re-trabecualtion.

FIG. 107.—*Case* 2. Tuberculous hip. Sixteen months' history. Radiograph taken 3½ years after operation. Note enormous hypertrophy of graft.

6. Mechanical.—Following an iliofemoral arthrodesis a dead space of disease may be left, composed of part of the head of the femur and part of the acetabulum. If this occurs it generally indicates that the operation has been performed prematurely—namely, before sufficient healing has taken place. Consequently

numerous cases have been recorded of iliac grafts having fractured or become displaced at either end. Possibly this is due to the fact that they have been subjected to too great a strain. In other words, an iliac graft depends for its success on the stability of the healed diseased area. This predicates the gradual change of diseased tissue to solid, weight-bearing bone. One knows that this can occur if the general resistance of the patient and healing capacity are sufficiently good. This factor, however, is not essential to the success of the ischiofemoral arthrodesis, and a successful ischiofemoral arthrodesis may help the resistance and healing capacity of the patient. One might go further, and say that a successful extra-articular iliofemoral arthrodesis is only possible in a healed lesion, and one is beginning to believe that an ischiofemoral arthrodesis is possible at any time after the first year of disease, and may determine the spread and extent of healing. It is too soon to state this dogmatically, but one cannot help being impressed by the very rapid change which occurs in the area of disease actually during the time that bony fusion is taking place. (*Figs.* 104–107.)

CONCLUSIONS

A method of arthrodesis of the hip by means of fusion between the ischium and the femur is advocated.

The results of the operation in 35 patients are published.

The advantages of the operation are discussed, and it is suggested that this operation is possible in many patients where the more usual iliofemoral arthrodesis cannot be performed.

THE COLLATERAL VENOUS CIRCULATION IN A CASE OF THROMBOSIS OF THE INFERIOR VENA CAVA, AND ITS EMBRYOLOGICAL INTERPRETATION

By J. A. KEEN

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SURVIVAL after complete obstruction of the inferior vena cava, involving as it does occlusion of both renal veins, must be very rare. A case, illustrating the remarkable venous anastomoses by which this had been achieved, was discovered in a dissecting-room subject, a coloured male, aged 71. There was nothing in the clinical history which gave any explanation of the causation of the venous thrombosis. The man was blind and had spent the last eleven years of his life at the Cape Town Infirmary, during which period there was no history of any serious disturbance in health. His last illness was a rather sudden heart collapse with pulmonary congestion.

The dissection of the posterior abdominal wall showed so many features of anatomical and embryological interest that a detailed study seemed warranted. The inferior vena cava was filled by a thick fibrous cord which completely blocked the vessel from its commencement to the entrance of the first hepatic vein near the diaphragm. The thrombosis with resultant fibrosis had also spread into the right common iliac vein and into both renal veins. In a monograph on veins (Franklin, 1936), thromboses of many of the large veins are discussed separately, but the inferior vena cava is not mentioned, and I have not been able to find any reference to other cases of inferior vena cava obstruction.

In the interior of the organized thrombus there was a central core of calcified matter. This may be called a phlebolith, although the more common calcified thrombi are little hard, spherical nodules lying in dilated veins, and almost free of attachment (Osler and McCrae, 1927). The lower $1\frac{1}{2}$–2 in. of the phlebolith, i.e., a portion opposite the thrombosed renal veins and for some distance above these vessels, filled the inferior vena cava completely. In the upper part of the inferior vena cava the bony rod became thinner, and in the blocked portion of the vein at the back of the liver the calcified matter occupied about one-fourth of the area of the cut surface.

A radiograph of the posterior abdominal wall (*Fig.* 108) showed that the calcified thrombus could just be distinguished against the shadow of the vertebral column. But it is doubtful whether a diagnosis could have been made during life.

A microscopic section of the occluded inferior vena cava below the phlebolith showed firmly organized fibrous tissue with no trace of a lumen, and the vein wall could not be recognized as such. A section higher up, near the lower border of the liver, showed the same changes, but the fibrous tissue has a well-marked non-cellular bony centre. The sections indicated an organized fibrous thrombus, in a completely inactive state, with an origin which certainly dated back many years. No deductions could be made as regards the pathology or as to the likely starting point of the thrombosis in the inferior vena cava.

At the point where the first hepatic vein from the right lobe of the liver joined the inferior vena cava there was a sudden transition to a large open vessel. The portal venous circulation was clearly normal. But the whole venous return from the kidneys, suprarenals, pelvic organs (except the rectum), and both lower limbs had to take place via the azygos veins and the superior vena cava. This collateral circulation had been successfully established.

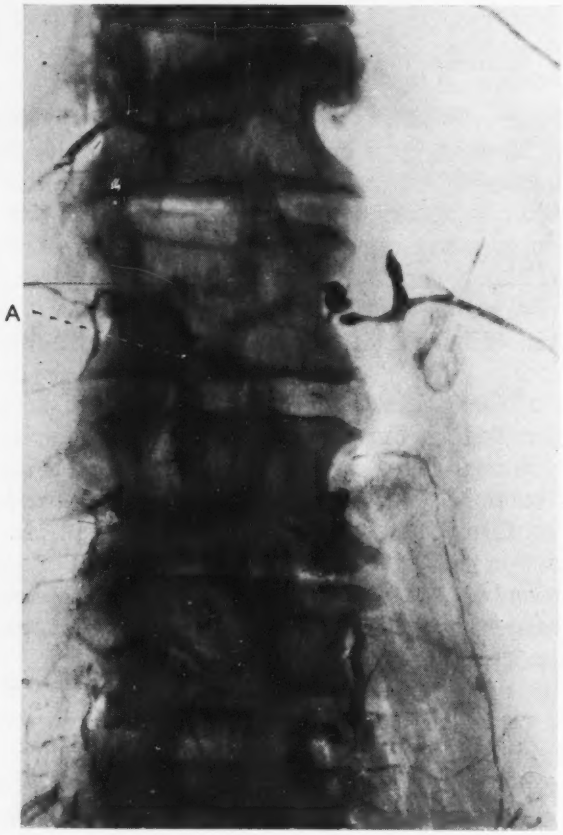

FIG. 108.—Radiograph of the posterior abdominal wall. The fibrosed and calcified inferior vena cava is fixed to the first lumbar vertebra with a pin. The aorta has been removed, but note the shadows of the lumbar arteries injected with starch and vermilion (mercuric sulphide) for dissection purposes. A, Phlebolith in the inferior vena cava.

DESCRIPTION OF THE COLLATERAL CIRCULATION

The key to the collateral circulation in this case was a plexus of veins deep to the crura of the diaphragm, and surrounding the beginning of the abdominal aorta; the larger veins of this plexus were behind the aorta on the bodies of the 1st and 2nd lumbar vertebræ. These veins will be referred to as the *prevertebral plexus*, but it might equally well be called the peri-aortic or retro-aortic plexus, all of which terms are used in anatomical descriptions of these veins.

Right Kidney.—The right kidney had established a new venous circulation by two routes: (1) The greater part of the kidney was drained by a dense network of small perinephric veins which pierced the fibrous capsule of the kidney and opened into a large right subcostal vein. On their way to the subcostal vein, these

small vessels pierced the origin of the diaphragm along the 12th rib (*Fig.* 109); the perinephric veins formed remarkable bunches of vessels in the perinephric fat all around the organ. (2) There was a small anastomotic vein (*Fig.* 109, A) which started from the open part of the right renal vein and passed behind the obstructed

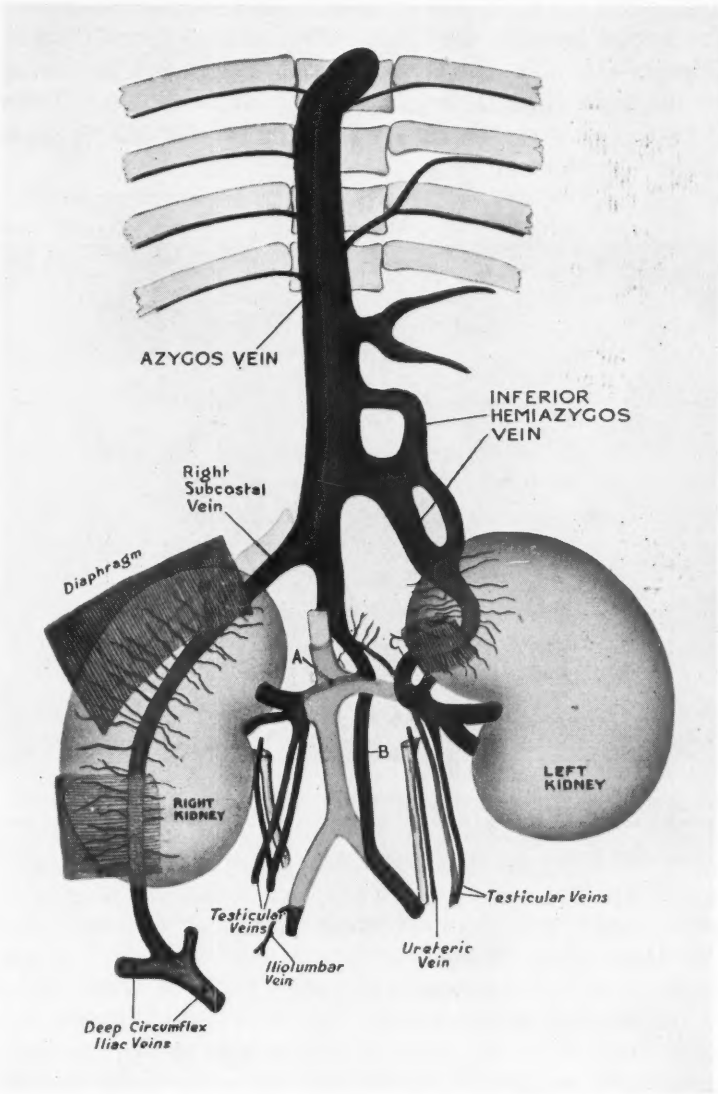

FIG. 109.—Veins of the posterior abdominal wall with the kidneys in situ (semi-diagrammatic). The fibrosed veins and the phlebolith are shown in yellow. For A, B, C, *see* text.

inferior vena cava; it then pierced the right crus of the diaphragm, crossed the median line on the body of the 2nd lumbar vertebra, and joined the vein marked B. The morphology of these veins will be discussed later.

A microscopic section of the right kidney (*Fig.* 110) showed perinephric fatty tissue with numerous dilated venules passing through the fibrous capsule. A part

of the kidney near the surface was non-functioning, as evidenced by dilated tubules filled with a colloid material and by sclerotic glomeruli. In the deeper parts of the kidney the glomeruli and tubules became normal in appearance. The change in the kidney tissue is one due to the vascular disturbance and there is no evidence of primary kidney disease. It may be presumed that the kidney swelled up considerably at the time when the renal vein became blocked, with pressure effects near the capsule. The surface layers of the kidney never recovered from that initial lesion.

Left Kidney.—This also had a double route for its venous drainage: (1) As a contrast to the right kidney, an anastomotic vein (*Fig.* 109, C) was the more important channel. This vessel arose from the posterior aspect of the open part of

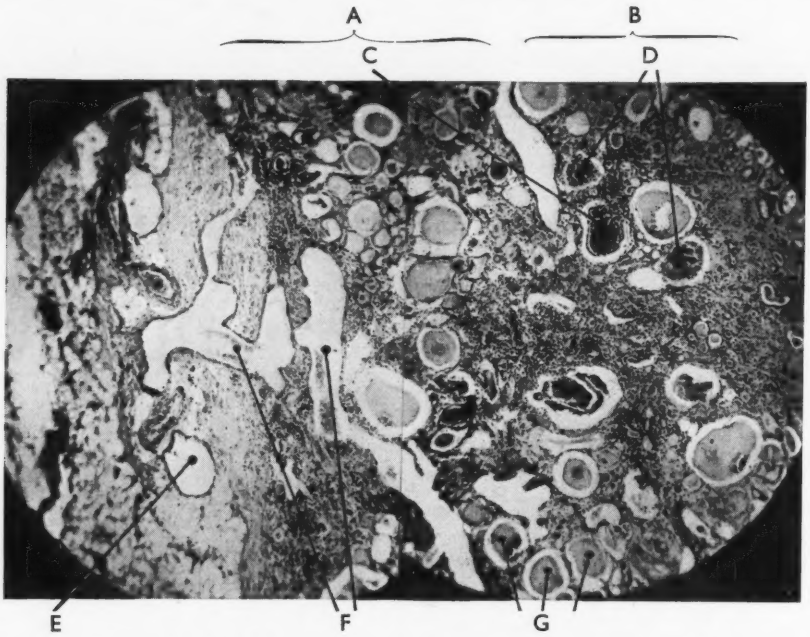

FIG. 110.—Section of a piece of the right kidney near the surface. A, Zone of non-functioning kidney tissue; B, Deeper zone of active kidney tissue; C, Sclerotic glomerulus; D, Functioning glomeruli; E, Vein in the perinephric fat; F, Vein piercing kidney capsule; G, Non-functioning dilated tubules filled with colloid.

the left renal vein and took a backward course close to the disc between the 2nd and 3rd lumbar vertebræ, i.e., in the anatomical position of the 2nd left lumbar vein deep to the psoas major muscle; it continued towards a plexus of veins which marked the beginning of the inferior hemiazygos vein. (2) Part of the left kidney near the upper pole was drained by perinephric veins similar in type to those on the right side; these perinephric veins, after piercing the posterior part of the diaphragm, joined the beginning of the inferior hemiazygos vein; there was no large subcostal vein on the left side.

Testicular Veins.—The testicular veins were large, double vessels on each side. On the right side, both testicular veins joined the open part of the right renal vein. On the left side, one testicular vein united with the open part of the left renal vein. The other left testicular vein passed behind the renal vein and joined a network of veins from the left suprarenal gland; these veins then pierced the left crus of the diaphragm and emptied into the prevertebral plexus.

The ureters were accompanied by abnormally large *ureteric veins* and these also joined the prevertebral plexus.

Pelvis and Lower Limbs.—Before the collateral circulation was investigated both lower limbs had been removed by students in the course of dissection. The study of the venous circulation on the right side was made still more difficult by the fact that the right hip-bone had been disarticulated for the dissection of the pelvis from that side. The cut ends of the external iliac and internal iliac veins and the distal part of the right common iliac vein were open vessels. The right common iliac vein was occluded proximal to the point where the iliolumbar vein joined it. Therefore the *right side of the pelvis* had an outlet via the open part of the right common iliac vein and the iliolumbar vein (*Fig.* 109); no doubt the enlarged ureteric veins also took on some of the venous drainage of the pelvis. The left common iliac vein was open except for a small portion close to the commencement of the inferior vena cava. The venous return from the *left side of the pelvis* therefore passed through the open part of the left common iliac vein and via the anastomotic channel B (*Fig.* 109). The left external iliac vein with blood from the left lower limb also had this route available.

The *right lower limb* was covered with dilated superficial veins. The students had noticed this at an early stage of the dissection, but the significance of these varicosities was not appreciated at that time. The difficulties of the venous return were obviously great, considering that the right common iliac vein was blocked to a large extent. Anastomotic channels had been opened up in connexion with the deep circumflex iliac veins. These anastomotic vessels formed a network of large veins in the muscles of the abdominal wall, and united above to form the large right subcostal vein. As this vessel also received the perinephric veins from the right kidney, it may be said to have replaced the right common iliac and the right renal veins.

Inferior Hemiazygos Vein.—This vein was represented by two large venous sinuses joined by cross channels (*Fig.* 109). They received the venous blood from the left kidney, a small left subcostal vein, and the veins from the 10th and 11th intercostal spaces. Both parts of the enlarged hemiazygos vein flowed into the azygos vein: the lower vein opposite the 11th thoracic vertebra, the upper one opposite the body of the 10th thoracic. The superior hemiazygos vein and the posterior intercostal veins of the right side showed nothing abnormal.

Azygos Vein.—The azygos vein had its beginning in the prevertebral plexus of veins behind the aorta. Opposite the body of the 12th thoracic vertebra it was joined by the very large right subcostal vein (*Fig.* 109). After receiving the inferior hemiazygos, the azygos vein became a very large vessel with a diameter at least twice the normal size. In the posterior mediastinum the azygos vein had the usual anatomical position, ending in the superior vena cava; the latter vessel therefore carried the venous blood from the whole of the body, with the exception of the blood from the portal system.

EMBRYOLOGICAL INTERPRETATION OF THE COLLATERAL CIRCULATION

We must assume that the obliteration of the inferior vena cava in this case was the result of a spreading type of thrombosis which involved the renal veins gradually, because a sudden blockage of both renal veins is incompatible with life

(Osler and McCrae, 1927). When fresh channels were required for the return of blood from the kidneys and from the lower part of the body to the heart, one method of compensation was the utilization of the venous plexuses in the perinephric fat for drainage through the kidney capsule. Another method was the formation of fresh channels along the vertebral column, or perhaps the re-opening of pre-existing ones. It seems reasonable to suggest that some of these channels represent a re-establishment of certain of the pathways of the primitive embryonic circulation.

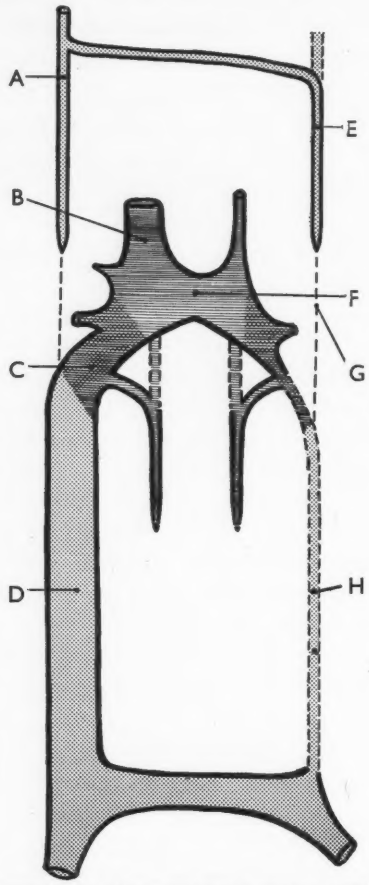

FIG. 111.—Fundamental ground plan of the embryonic venous circulation. The veins in the main venous line (posterior cardinal, supra-cardinal or perigangliomic, azygos line), and the subcardinal system are indicated by different forms of shading. A, Azygos vein; B, Pre-renal segment (right subcardinal vein); C, Renal segment; D, Post-renal segment; E, Inferior hemiazygos vein; F, Subcardinal anastomosis; G, Represented by vein C in *Fig.* 109; H, "Left inferior vena cava" (represented by vein B in *Fig.* 109).

A brief account of the development of the inferior vena cava, as given in modern text-books of embryology, may not be out of place. It involves the study of three paired longitudinal veins which are associated with the primitive kidneys in succession. These are the *posterior cardinal veins* belonging to the cardinal system, the *subcardinal veins*, and the *supracardinal veins* in this chronological order of appearance (Arey, 1930; Keith, 1933; Simkins, 1931). The supracardinal veins are also called the *perigangliomic plexus*, on account of their close proximity to the sympathetic trunk (Frazer, 1940). All the three systems of longitudinal veins

are represented in the inferior vena cava ; this vessel is divided embryologically into a *post-renal segment*, a *renal segment* in the region of the renal veins, a *pre-renal segment* above the renal veins (*Fig.* 111), and lastly a *hepatic segment* not shown in *Fig.* 111.

The post-renal segment contains a very small part of the right posterior cardinal vein near the commencement, the remainder being the surviving part of the right supracardinal vein. The renal segment is an anastomosis between the right supracardinal and the right subcardinal veins. The pre-renal segment is partly the right subcardinal vein and partly a special anastomosis between the right subcardinal vein and the common hepatic vein. The hepatic segment is formed from the common hepatic vein, which is originally derived from the vitelline veins. In accounts of this chapter of embryology by other authors (Brash in Cunningham's *Anatomy*, 1937 ; Gray, 1938) the description includes several primitive longitudinal veins in addition to the three cardinal veins.

REVIEW OF THE LITERATURE

Many previous articles dealing with the development of the inferior vena cava (Gladstone, 1911 and 1929 ; Cameron, 1911) were studies of abnormalities of the vessel, such as bilateral post-renal venæ cavæ, persistence of a left supracardinal vein, abnormal positions of the inferior vena cava in relation to the common iliac artery or to the right ureter, with explanations of these abnormalities on embryological grounds. The present instance appears to be unique because it allows one to approach the embryological problem from an entirely new angle. Instead of dealing with an anomaly of the inferior vena cava, we have to do with a normal vessel which has become obliterated, and the pattern of the collateral circulation which became established has to be resolved in terms of our knowledge of human embryology.

There are three original papers, two published in America (1920 and 1925) and one in Great Britain (1929), which were mainly responsible for enlarging our knowledge of the embryology of the inferior vena cava and its tributaries. Up to that time only the " posterior cardinal veins " lying on each side of the aorta and the easily recognizable subcardinal veins ventral to the mesonephros were thought to be concerned in the development of the inferior vena cava. Many new longitudinal trunks were discovered in the venous networks around the developing mesonephros and metanephros, and these veins were given new names. Our knowledge became enlarged, but the understanding and teaching of this branch of embryology became enormously complicated, because the original posterior cardinal and subcardinal ground plan was destroyed.

Huntingdon and McClure (1920) are the originators of the term " supracardinal vein " and " renal collar." These authors studied the development of the inferior vena cava in the cat. A pair of longitudinal veins which developed a little dorsal and medial to the posterior cardinal veins, but still lying in the original posterior cardinal line on each side of the aorta, were called by them the " supracardinal veins." At the cephalic end near the duct of Cuvier and at the caudal end near the beginning of the future inferior vena cava, the supracardinal vein opens into the posterior cardinal vein. The intermediate piece of the posterior cardinal vein is said to disappear. The two supracardinal veins have numerous cross

anastomoses behind the aorta. A post-aortic cross channel in the region of the renal veins and anastomoses between the supracardinal, posterior cardinal, and subcardinal veins at the same level tend to persist. These anastomoses, together with the intersubcardinal anastomosis ventral to the aorta, establish the presence of a circumaortic venous ring which the above authors have called the " renal collar ". Huntington and McClure also state definitely that the supracardinal veins in the thoracic region are the forerunners of the azygos veins.

McClure and Butler (1925) studied the development of the inferior vena cava by means of laborious and painstaking reconstructions of the venous patterns in fifteen human embryos ranging from 4 mm. to 45 mm. They accepted the definitions of " supracardinal veins " and " renal collar " and these terms became incorporated into human embryology. An examination of the wax models illustrated in the article gives one the impression of immense networks of small veins which tend to coalesce along irregular longitudinal lines, and these lines shift from time to time as growth-changes in the mesonephros and metanephros necessitate such displacements. If sufficient human embryonic material became available and it was thought profitable to pursue this line of research, there is little doubt that intermediate stages between posterior cardinal, subcardinal, and supracardinal veins could be discovered, with further complications of terminology. The study of the embryology of these veins, e.g., in the cat, was carried to such lengths that Huntingdon and McClure (1920) were able to describe 17 different types of inferior venæ cavæ, most of which have been found in adult cats by them or by other observers.

Gladstone (1929) describes several different anomalies of the inferior vena cava, and at the same time gives a review of the developmental history of this vessel. Some of this author's statements and expressions of opinion are so significant that I intend to quote freely from his article. Gladstone recognized the importance of two anastomotic veins which are frequently found on the posterior abdominal wall. One, on the right side, arises from the dorsal aspect of the inferior vena cava and proceeds upwards through the right crus of the diaphragm, or its aortic opening, to join the azygos vein in front of the body of the 12th thoracic vertebra. The other, on the left side, often springs from the dorsal aspect of the left renal vein and passes through the left crus to the inferior hemiazygos vein. Gladstone suggests the special names of " right " and " left azygos lumbar veins " for these vessels, and these terms are now part of our general anatomical knowledge.

The author also states that " the account of the development of the post-renal segment of the vena cava has been rendered more difficult by different names having been applied to the same venous channels. This difficulty could be removed to a certain extent if the term inferior vena cava be applied to the main venous channel in the embryo, as soon as the definitive course is established " (op. cit., p. 85). Gladstone finds that late human embryos (22 mm. or older) show post-aortic anastomoses between the right and left inferior venæ cavæ and these anastomoses are identified with the " supracardinal veins " of Huntington and McClure. No clear evidence is brought forward for the existence of a complete venous channel in the human embryo which could be called " supracardinal ". An examination of Figs. 1, 2, and 4 on Plate II of Gladstone's article (transverse sections of human embryos, 19 mm. and 22 mm.) leaves one in no doubt that the right and left " azygos veins " on each side of the aorta lie in the same morphological plane as the right

and left " inferior venæ cavæ " on each side of the aorta at a lower level. In a much earlier article by the same author (1911), Fig. 5 is a transverse section of a 10-mm. human embryo showing characteristic large posterior cardinal veins dorsal to the mesonephros but already in the typical position on each side of the aorta. Fig. 6 in the same article is a transverse section of a much older human embryo about the eighth week (i.e., about 25 mm.). The kidney now lies lateral, but the two venous trunks are still in the original position on each side of the aorta ; the right one large and representing the inferior vena cava, the left one small and in process of disappearing.

I cannot agree with Gladstone's statement that " the normal position of the sympathetic trunks in the human subject dorsomedial to the inferior vena cava precludes the possibility of the derivation of this part of the vena cava from an embryonic vein lying in the true azygos line " (op. cit., p. 87). A further objection which he puts forward concerns the anatomical position of the nerves from the sympathetic trunk. The greater and lesser splanchnic nerves pass in front (ventral) of the azygos veins from the lateral side, while the tributaries from the lumbar sympathetic trunk to the aortic and hypogastric plexuses pass medial to the inferior vena cava. These arguments are easily answered. At the embryonic stage when the longitudinal veins in question are clearly seen on each side of the aorta, the sympathetic nerves have not yet begun to grow out. In Fig. 1 (Plate II) of Gladstone's article the sympathetic trunk is seen lying against the vertebra a little lateral to the primitive azygos veins. In Fig. 2, a transverse section through the abdominal region, the sympathetic trunk has shifted on the vertebra nearer to the median line and lies directly behind the primitive inferior vena cava, a change in position which presents nothing surprising. When the sympathetic nerves grow out at a later period they will choose the pathway which is the easier, i.e., across the " azygos veins " in the thoracic region and between the " inferior vena cava " and aorta in the lumbar region.

EXPLANATION OF THE COLLATERAL CIRCULATION IN *Fig.* 109

In view of what has been stated above there should be no difficulty in regarding the post-renal segment of the inferior vena cava as lying in the same ' line ' as the azygos veins, i.e., in the anatomical line of the original posterior cardinal vein. In this respect I am in agreement with Drennan (1927) and Grant (1937), who retain the original posterior cardinal-subcardinal ground plan in their respective textbooks, whilst no doubt recognizing that minor alterations in the position of the main venous trunk have taken place as these veins established themselves across changing venous plexuses. In my conventional diagram (*Fig.* 111) a main venous line in the position of the original posterior cardinal veins, i.e., on each side of the aorta, is retained as a basic feature.

Using the diagrammatic *Fig.* 111 as a guide, the interpretation of the collateral circulation in my case of obstructed inferior vena cava becomes quite straightforward. The *prevertebral plexus* which I have earlier on spoken of as the key to the collateral circulation may be identified with the post-aortic part of the " renal collar " of Huntingdon and McClure. Vein B (*Fig.* 109) represents a " left inferior vena cava ", the counterpart of the post-renal segment of the inferior vena cava (*Fig.* 111). Higher up vein B joined the prevertebral plexus of " renal collar " which is not

shown in *Fig.* 111. The position of vein B closely resembles that of an abnormal vein found in a dissecting-room subject by Cameron (1911). This author, writing before the publication of the Huntington, McClure, Butler, and Gladstone researches, reported the condition as the persistence of a left posterior cardinal vein.

Vein A (*Fig.* 109) is also part of the " renal collar ". Vein C is best explained as a dilated left lumbar azygos vein, and is thus the thoracic continuation of the main venous line on the left side (*Fig.* 111). Multiple *testicular veins* are explained by Huntington and McClure as related to atypical conditions of the embryonic subcardinal veins. On the right side both testicular veins terminated in the " renal collar " ; on the left side, one of the testicular veins joined the " renal collar ", the other ended in the usual anatomical position.

From the embryological point of view, the only part of the inferior vena cava which was present as a functioning vessel in the circulation under discussion was the hepatic segment. If the inferior vena cava becomes obstructed, it is easy to understand, on embryological grounds, that the right side of the body will be more embarrassed than the left side. On the right side the embryonic veins have become incorporated in the inferior vena cava and are not available, if this vessel becomes thrombosed. On the left side, on the other hand, remnants of the embryonic pattern may be present as small anastomotic vessels which can become dilated in case of necessity. This seems to offer a reasonable explanation of the difference in compensation on the two sides, as evidenced by the extreme varicosity of the right leg and the absence of this on the left leg.

SUMMARY

A rare case of thrombosis of the inferior vena cava with fibrous tissue formation and calcification is described, together with X-ray findings and accounts of the microscopical sections of the thrombosed vessel and of the kidney showing the perinephric venous circulation. The collateral circulation which became established on the posterior abdominal wall is traced and illustrated. The literature on the development of the inferior vena cava is reviewed, and this is followed by an embryological explanation of the collateral circulation on the basis of a simplified ground plan.

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INTRACAPSULAR FRACTURES OF THE NECK OF THE FEMUR

FINAL RESULTS OF 75 CONSECUTIVE CASES TREATED BY THE CLOSED METHOD OF PINNING

By A. L. EYRE-BROOK and K. H. PRIDIE
BRISTOL ROYAL HOSPITAL FRACTURE SERVICE

The study is confined to the first 75 consecutive cases of fractured neck of the femur (excluding lateral or extracapsular fractures) which have been treated by the Bristol Royal Infirmary Fracture Service by the Hey Groves method of pinning, and which have been followed up for a minimum period of twelve months.

During the period under investigation, the Smith-Petersen pin has been the routine treatment for this fracture, and no special selection of cases has occurred. Only those were refused operation whose general condition was so poor as to render this slight operation an unwarranted risk.

We believe that a follow-up of twelve months allows all complications to manifest themselves, although many will not have run their course.

As full a follow-up as possible has been attempted :—

1. Examined by one of us (E.-B.)		52 (X-rayed, 47)
2. Not examined because :—		
a. Died before follow-up	17	
Questionnaire filled in by relatives	15	
Died whilst still in hospital	2	
b. Lived too far away. Questionnaire filled in	4	
c. Untraced	2	
		75

PROCEDURE

Pre-operative Treatment.—On admission most of the cases are put up in extension, using the method introduced by Hamilton Russell, of Melbourne. Extension Elastoplast is used, no skeletal traction being advocated. A complete or partial reduction of the fracture results.

Operation is carried out on the first routine operation day, allowing of a maximum delay of seven days, except in cases where multiple injuries or other complications necessitate postponement.

Operation.—The operation is, as a rule, performed under general anæsthesia. The fracture is reduced by Leadbetter's method. Following reduction, the leg is held by a nurse, seated comfortably on a stool, with her two hands clasped behind the bent knee and with the vertical lower leg to the outer side of her legs, thus maintaining slight internal rotation (*Fig.* 112). By leaning slightly backwards, the nurse maintains a little traction on the leg, and the leg is in about 15° of abduction. It is essential that the stool is suitably placed and does not slip. The position, we are assured, is quite comfortable, and requires no experience to adopt and

maintain for the average period of 20–30 minutes. We have had no trouble with this method of fixation, although we are working on a mechanical fixation in this position.

The pin is introduced by the Hey Groves method, which we consider to be a very great contribution to the fracture surgery of the hip. Exceedingly ingenious, safe, and simple, it provides a closed method of introducing the Smith-Petersen pin which can give consistently reliable results, with the minimum of X-ray and technical assistance. Two points may be stressed in connexion with this instrument. One is that the femoral artery is in no danger at all, as it always moves medial to the femoral point in an abducted leg, and is always palpable and so readily avoided; if the anterior crural nerve has ever been perforated it has never given symptoms in our cases. The second point is that the ends of the perforating pins in the Hey Groves introducer must have a very obtuse bevel to avoid penetrating the relatively soft cortical bone of the elderly patients.

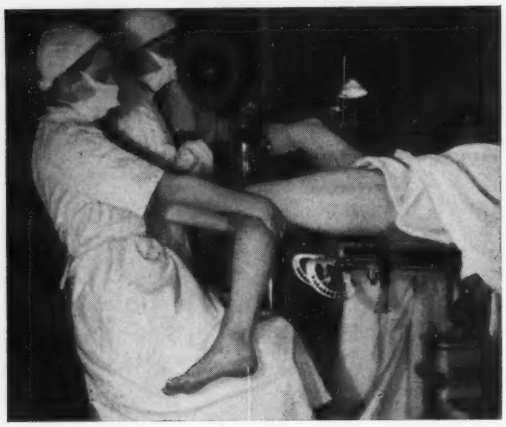

FIG. 112.—Nurse holding leg after reduction, while lateral radiograph is about to be taken.

The pin used is of non-toxic, stainless steel, and has a special head designed by one of us (K. H. P.). The features of this pin are (*Fig.* 113):—

1. The head is lengthened so as to get the groove, into which the teeth of the extractor have to engage, away from the shaft of the femur.

2. The head is bevelled on its deep surface, so as to lie snugly in contact with the shaft of the femur, thus assisting in impaction and avoiding comminution of the cortical bone.

A minimum of five radiographs are taken, two to check the reduction and obtain the position of the Hey Groves hinged marker and the Watson-Jones graduated measuring rod; two to check the position of the guide wire; and a final one to check the distance to which the pin has penetrated. Most cases require five or seven films, the latter allowing for one manœuvre being repeated. Some of the cases have been done by one of us (K. H. P.) with less than five films in order to shorten the time of operation, a procedure which is now condemned.

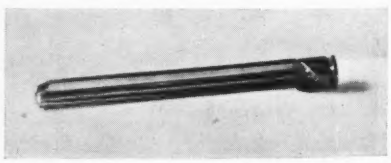

FIG. 113.—Pridie's modification of the Smith-Petersen pin (obtainable from Messrs. Down Bros.).

Post-operative Treatment.—No external fixation is employed, and the patient is encouraged to use his leg after the first few days, the leg lying on a pillow.

Physiotherapy and assisted active movements were formerly advised, but are now discouraged, as this undue haste appears to throw a dangerous and unnecessary strain on the fracture and its immobilizing pin.

As a routine, no weight-bearing is allowed for three months, but variations from this standard have occurred, and are discussed later. Crutches are allowed at a much earlier date, so long as no weight is borne on the affected leg.

RESULTS

Our standard for a successful result is a case followed up after a minimum period of twelve months, and falling into one of the following groups :—

1. A case in which the radiograph shows bony union (trabeculation and loss of fracture line) and no signs of necrosis of the head or other complications.

In all such cases movement of the hip ranged from 80 to 100 per cent, and pain was absent in all but 2 cases, where it consisted of a slight aching. There were 28 cases in this group.

2. A case which could not be X-rayed, but which had a range of movement in the hip of over 80 per cent, and nothing more than an occasional ache. There were 5 cases in this group, and the follow-up period proved in no case to be less than 26 months.

3. A case neither X-rayed nor examined, but reporting little or no ache, full activities for age and circumstances, and a free range of movement. There were 5 cases in this group, and the follow-up period proved in no case to be less than 22 months.

Bony union occurred in 44 cases, i.e., 58·7 per cent.

If we exclude doubtful cases, including those which died without union having failed, then bony union occurred in 70 per cent of the remainder.

	No. of Cases
Successful results	38 (50·7 per cent)
Bony union, but necrosis of the femoral head	5 (6·7 per cent)
Bony union, but pin penetrated joint, causing arthritis	1 (1·3 per cent)
Failed pinning	6 (8·0 per cent)
Fibrous union	10 (13·3 per cent)
Local suppuration and non-union	3 (4·0 per cent)
Died without further operation within four months	4 (5·3 per cent)
Doubtful end-results	8 (10·7 per cent)
Consecutive cases examined	75 (100 per cent)

Results in Detail		*No. of Cases*
Successful results		38
Examined; radiographs showed bony union	28	
Examined, but not X-rayed (interval since operation, 26, 30, 35, 39, and 47 mths.)	5	
Adjudged on answers to questionnaire (2 still living; 2 died 21 and 22 mths. after operation)	5	
	38	
Cases showing necrosis of the femoral head		11
Necrosis with bony union	5	
*Necrosis with fibrous union or non-union †(one penetrating pin)	6	
	11	
Cases of failure of union		16
Failed pinning (early failure of pin to immobilize fracture)	6 (2 died)	
Fibrous unions without necrosis	2	
*Fibrous union or non-union with necrosis of head †(one pin penetrating)	6	
*Fibrous union with pin perforating hip-joint	2	
	16	

* Cases that appear twice, i.e., fibrous union and necrosis.

Cases in which pin penetrated into hip-joint causing arthritis		4
With bony union, pin initially very deep	1	
*With much absorption of neck and eventual doubtful union	2	
†With fibrous union and complete necrosis of head	1	
	4	
Cases in which local suppuration led to non-union		3
Cases which died as the result, direct or indirect, of the accident		6
1. From pulmonary embolism on 10th day.		
2. From bronchopneumonia in the 4th week.		
3. From cerebral thrombosis, after 2½ mths.		
4. From general debility and bed-sores after 3 mths.		
Following subsequent operations (previously listed under non-unions).		
5. *Failed closed pinning—open reduction and re-pinning—died 2 weeks later.		
6. *Failed closed pinning—McMurray's osteotomy—died 4 months later.		
Cases in which results were not ascertained		8
Untraced	2	
Died after various periods (4½–25 mths. after operation)	5‡	
Questionnaire—Case living at a distance	1‡	

* Cases that appear twice, i.e., fibrous union and necrosis.
† Cases that appear three times, i.e., fibrous union, necrosis, and perforating pins.
‡ In each case questionnaire failed to establish a definite success or failure.

The cases are listed in *Table I*, and data in each column are assessed in the following paragraphs. In the original table consideration was also given to the position of the fracture in relation to the neck, this being divided into thirds, subcapital, trans-cervical, and basal. No useful purpose was found to be served, in view of the fact that in all but 2 cases the fracture was classified as trans-cervical. In most cases the fracture lay somewhat obliquely to the neck, but mostly in the middle third.

The displacement at the fracture site was also investigated in an attempt to correlate this with impairment of the blood-supply and complications, but in view of the infrequency of lateral radiographs in the initial examination, no real data on the subject could be collected.

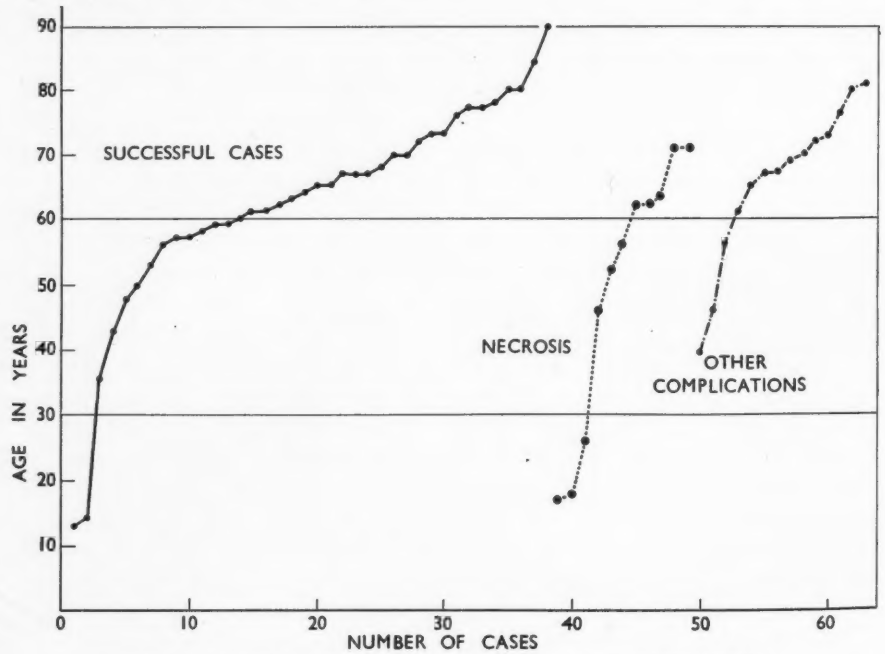

FIG. 114.—Graph showing the relationship of age to the results obtained.

Age.—The accompanying graph (*Fig.* 114) shows the relationship of age to results and brings out the interesting fact that while the percentage of complications other than necrosis increases with age, necrosis accounts for more disasters in youth.

Below 30 years of age	5 cases	Necrosis in 60·0 per cent
Between 30 and 60 years	18 cases	Necrosis in 16·7 per cent
Between 60 and 90 years	40 cases	Necrosis in 12·5 per cent

Day of Operation.—An investigation of this point revealed no information suggesting that moderate delay had a controlling influence. Actually, successful results followed pinning on the 29th and 33rd days, while 4 cases of necrosis occurred in patients pinned, two on the 2nd day, one on the 4th day, and one on the 35th day. This last case was one of those which developed sound bony union.

Interval Without Weight-bearing.—Supporting the horticultural rather than the joiners' attitude towards the pinned femur, we have as a rule adopted three months as the period during which the affected limb should be spared all weight-bearing. We have, however, in this series, 5 cases where weight was borne at a very early date (1–4 days). One case (aged 16½) developed a severe necrosis of the femoral head, while 4 (35, 48, 56, and 59 years) progressed to successful results. Incidentally all these four cases had a fracture-shaft angle (*see* later) of 43° or over, and were over 35 years of age. They were fractures in which circumstances were so favourable that one could apparently take liberties without ruining the result.

Angle subtended by the Fracture Line to the Shaft of the Femur (*Fig.* 115).—This angle can be read with ease on any antero-posterior radiograph of the reduced fracture (*Fig.* 116, A, B).

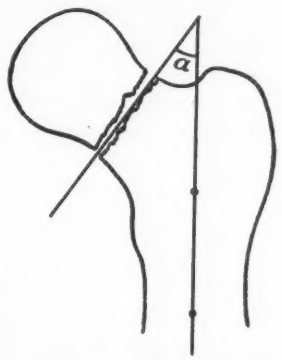

FIG. 115.— Fracture-shaft angle: One line follows the fracture surface on the shaft fragment, and the second line is the axis line of the femoral shaft.

Pauwel's angle can only be read on a special radiograph showing the whole pelvis and the injured femur in their normal relationship when in the standing position, but the above angle can be obtained from any reasonable series of radiographs. The fracture-shaft angle is almost the complement of Pauwel's angle.

It may well be objected that this angle is not an accurate index of thrust and shearing forces to which the fracture is to be subjected, as the femoral shaft is not always held in the same relationship to the vertical. This variation can be but slight, and does not materially affect the use of the angle as a practical index of the inherent tendency of the fracture to slip. King points out, in connexion with Pauwel's angle, that one must remember to visualize the fracture in space, and there may be some considerable shearing force concentrated in the plane shown in the lateral view.

Angle subtended by the Fracture Line to the Neck of the Femur (*Fig.* 117).—In order fully to assess the inherent tendency of any fracture to slip, a lateral view showing this angle is also necessary. All the radiographs were re-examined from this point of view. In 42 in which this angle could be measured, it was found that in 24 the fracture line was virtually transverse (angle above 80°); in 15 it was inclined so as to look posteriorly; and in only 3 did it look anteriorly.

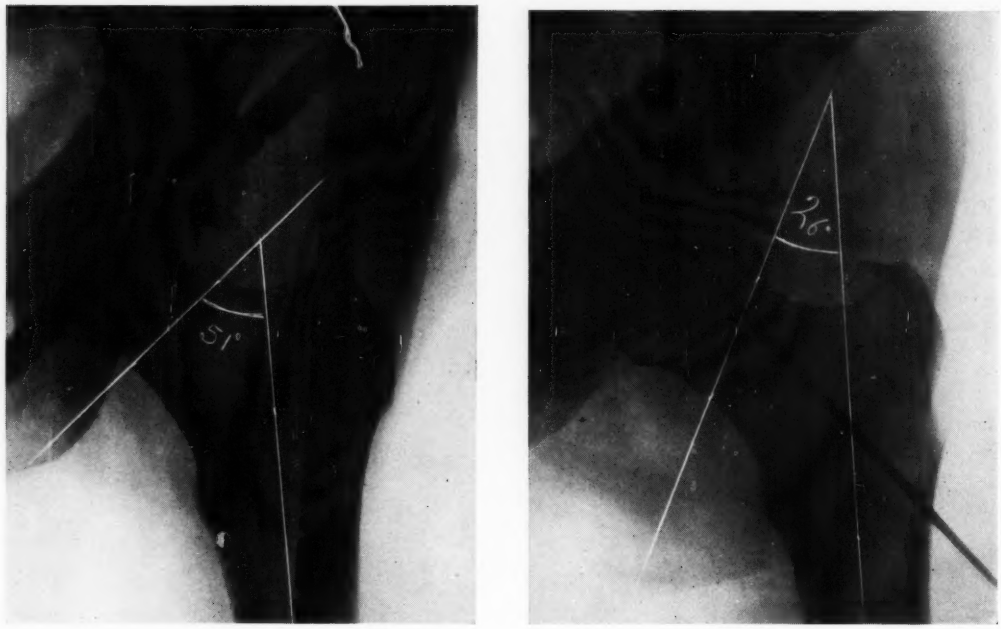

FIG. 116.—A, The fracture-shaft angle can only be read with the external rotation corrected. It is here shown to be 51°, and it is to be noted that it has no relation to the reduction, being controlled only by the nature of the fracture. (This radiograph shows the Hey Groves hinged marker.) B, This shows a low fracture-shaft angle with much shearing acting on the fracture line. (Also shown is the Watson-Jones guide in position prior to the introduction of the pin.)

The smallest angle subtended by the line of the fracture to the axis of the neck was 57°. In only one case was there any comminution of the posterior cortex. It was not possible to discover any prognostic importance of this fracture-neck angle in the 42 cases examined.

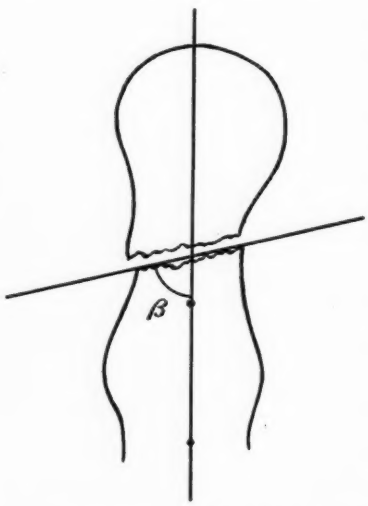

FIG. 117.—Fracture-neck angle: One line follows the fracture surface on the shaft fragment, and the second line is the axis line of the neck.

Reverting to the fracture-shaft angle, this is shown on the accompanying graph (*Fig.* 118), plotted against the number of cases. Three curves are shown: (1) One of the successful cases; (2) One of the cases of necrosis; (3) One of the cases of failed pinning and fibrous union.

The graph illustrates the following important findings:—

Fracture-shaft Angle	*Cases*	
0°–10°	1	Too few cases
10°–20°	2	Too few cases
20°–30°	16	Successes account for 18·8 per cent
30°–40°	24	„ „ „ 75·0 „ „
40°–50°	11	„ „ „ 100·0 „ „
50°–60°	4	„ „ „ 100·0 „ „

The importance of these angles, stressed by Pauwel, is fully borne out by the graph. Excluding

the cases of suppuration, where failure was evidently due to other causes, there is no complication in any case having a fracture-shaft angle greater than 37°.

The importance of this angle quite clearly outweighs nearly every other factor, and should control the treatment given. Where the angle is below 30° some modification of the simple Smith-Petersen pinning, either the addition of a bone-graft or a subtrochanteric osteotomy, to increase the angle, ought probably to be employed.

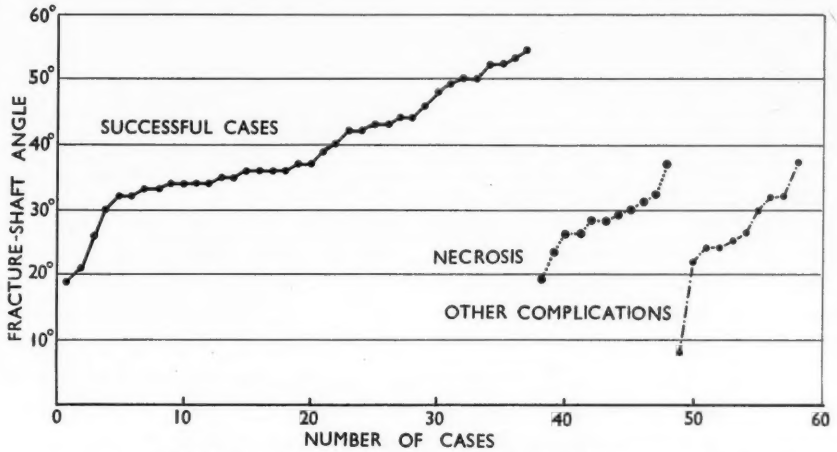

FIG. 118.—Graph showing the fracture-shaft angle plotted against the number of cases.

Reduction and Position of Pin.—These questions will be considered under an analysis of the failures.

Removal of Pin.—In 32 cases the pin was removed for the following reasons :—

1. Youth of patient	4
2. Pin displaced—fracture slipped	8
3. Pin loose and slipped back in track—fracture unaffected	2
4. Pin tending to penetrate into joint	8
5. For local suppuration	2
6. For necrosis of head	4
7. For no clear clinical reason (often for unexplained pain)	4
	32

The pin has usually been removed in all young cases, as it seemed inadvisable to carry this foreign body throughout life.

Some of the early pins were badly corroded, but more recently the stainless steel pin was always found to be bright and clean, and offered no suggestion that it could not advisably be left in place in more elderly patients. Other than for reasons of youth, the pin was only removed for some threatened complication, except in 4 cases where no clear reason can be discovered from the notes and radiographs, and the persistence of pain is the probable explanation.

Clinical Examination.—Complaints of pain and limited function were absent or of a very minor nature in all cases with bony union without complications. These cases had a range of movement between 80 per cent and 100 per cent.

Those with complications had a varying degree of disability and complaint. As in osteochondritis deformans juvenilis, Cases 39 and 40 are good examples of youths with badly deformed heads, and as yet only moderate limitation of movements and scanty complaints.

ANALYSIS OF FAILURES

(*Figs.* 119–130)

1. Necrosis (14·7 per cent).—Two features must be noted in connexion with this complication : (*a*) The incidence varies inversely with age ; (*b*) All cases had a fracture-shaft angle below 37°.

Reduction and fixation of the pin left nothing to be desired in 3 of the cases, and it is to be noted that 5 of the 11 cases obtained firm bony union. This union may be of the nature of creeping substitution of the dead head, the process not having involved the whole head before additional use and increasing brittleness of the dead bone results in collapse and distortion.

There are three points to observe in a radiographic series of a case of necrosis : (*a*) The radiological signs of necrosis ; (*b*) The onset of necrosis-collapse ; (*c*) The preservation or loss of the joint space.

The radiographical signs of necrosis preceding collapse consist of increased density, lack of distinction in trabecular outline, and a certain mottling, and we have evidence in all but one case that these signs were present within the year, in one case within two months.

The first appearance of signs of necrosis and the advent of collapse in the radiographs vary much as regards their time relationship, and the former are no transitory manifestation, as has been suggested by some.

These factors are represented diagrammatically in *Fig.* 119.

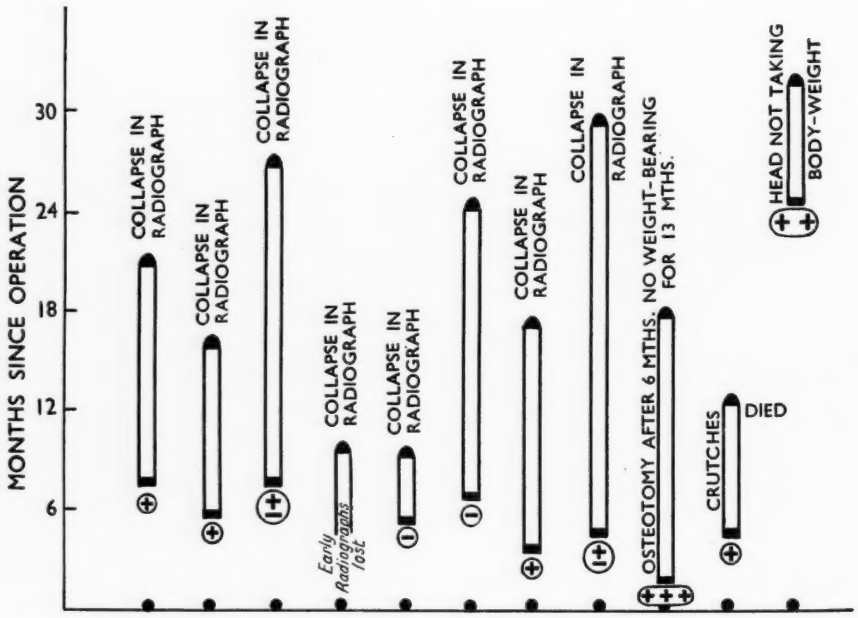

FIG. 119.—Showing diagrammatically the time of appearance of radiographic evidence of necrosis and of collapse.

± means doubtful evidence of necrosis in radiograph.
+ means evidence of necrosis in radiograph.
++ and +++ mean much evidence of necrosis in radiograph.

The earliest signs of necrosis occurred at 2 months in a case of massive necrosis (C. W.), while there are cases showing no signs at the 6th and 7th months, although

FIG. 120.—*Case* 39, R. H., aged 17 years. Radiograph 8 months after operation. Bony union. Signs of necrosis in lack of trabecular definition.

FIG. 121.—Same case 21 months after operation. Necrosis and collapse of the epiphysis and metaphysis. Joint space little diminished in depth.

FIG. 122.—*Case* 40, P.M., aged 17 years. Radiograph taken 6 months after operation. Bony union. Note line of demarcation between live and dead trabeculæ in the neck, considerably proximal to the fracture site.

FIG. 123.—Same case, 16 months after operation. Bony union, necrosis, and collapse. Joint space is distorted, but of normal depth.

FIG. 124.—*Case* 42, J. Ne., aged 56 years. Radiograph taken 6 months after operation. Bony union, no clear signs of necrosis.

FIG. 125.—Same case, 9 months after operation. Bony union, necrosis-collapse of head. Joint space is distorted, but undiminished in depth.

FIG. 126.—*Case* 47, C. W., aged 26 years. Radiograph taken 2 months after operation. Massive necrosis of the head.

FIG. 127.—Same case, 2 months after operation. Lateral view.

they eventually manifested necrosis-collapse of the head and neck. The earliest example of this collapse occurred at 9 months, while it may be indefinitely postponed and even avoided by absence of weight-bearing.

In one case of massive necrosis (C. W.) the joint space became markedly reduced, so that in spite of the absence of collapse, the result of no weight-bearing for 12 months, the hip was quite stiff. In the other cases the joint space remained largely unreduced, although distorted.

2. Failed Pinnings (8 per cent) (*Figs.* 131–136).—This group comprises cases where the pin failed to immobilize the fracture, as was shown by changes occurring within a few days or weeks. There are 6 cases and they illustrate: (*a*) Some really low fracture-shaft angles; (*b*) Some technical faults in reduction or in position of pin, giving rise to separation of fragments.

FIG. 128.—Same case. Massive necrosis 16 months after pin operation, since when he has had thyroidectomy for a toxic thyroid and an intertrochanteric osteotomy. No weight-bearing had occurred and therefore there is no collapse. Head appears largely revascularized. Note reduction in joint space. Clinically fibrous ankylosis.

Each case was primarily condemned to failure, either from the grossness of one technical fault or from the association of several less pronounced faults with a low

FIG. 129.—*Case* 41, M. S., 12 months after operation. Bony union, necrosis-collapse without reduction of the depth of the joint space.

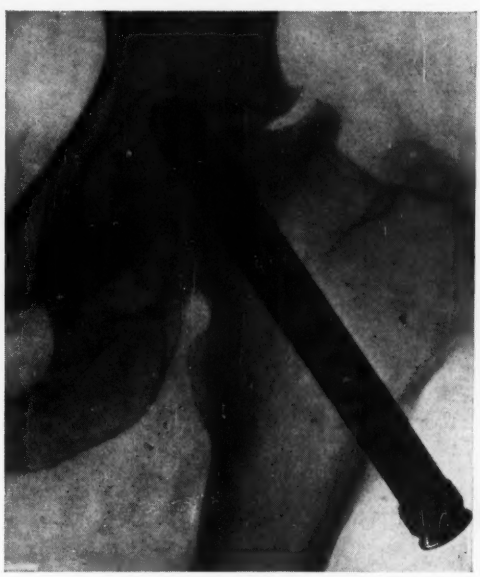

FIG. 130.—Same case, 24 months after operation. Necrosis-collapse of head, pin penetration of the joint. Joint space is distorted, but unreduced in depth.

fracture-shaft angle. These technical faults can certainly be avoided with more careful work, a great deal too much importance having been laid on the rapid execution of the operation during the period covered by most of these cases.

	Reduction	*Pinning*	*Fracture-shaft Angle*
1. M. C.	(*Fig.* 134) Good	High and short	25° (or less)
2. S. E.	(*Fig.* 133) Poor	High	22°
3. E. F.	(*Fig.* 132) Good	Poor, too posterior	8°
4. E. R.	(*Fig.* 131) Good	Too posterior	32°
5. P. F.	(*Fig.* 135) Good	Too short and too low	37°
6. M. P.	(*Fig.* 136) Poor	Not into head	30°

FIG. 131.—*Case* 50, E. R. Pin too posterior.

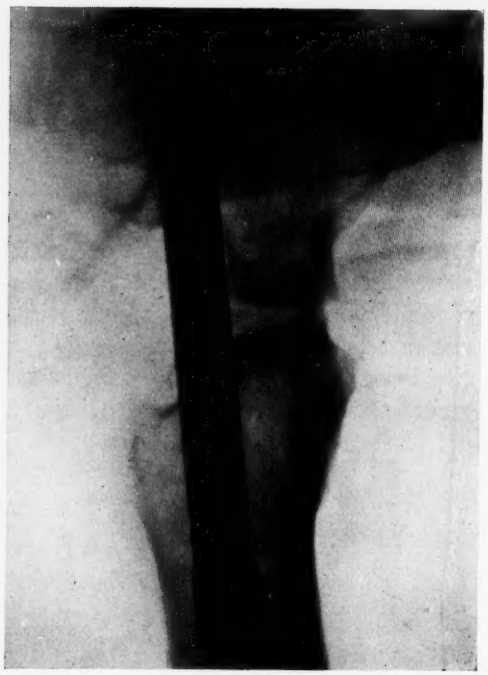

FIG. 132.—*Case* 51. E. F. Pin too posterior.

These may be the result of the proximal pin entering the fracture site, or of an over-sharp pin penetrating the thin cortex—a very obtuse bevel is essential.

3. Fibrous Union (13·3 per cent).—We have 10 cases of fibrous union. There were 2 clear cases of fibrous union without complications. There were also 6 with necrosis, and 2 with the pin penetrating the joint. In the first 2 cases there were no clear causes for failure of bony union, the reduction and the position of the pin appearing to be entirely satisfactory. In both the fracture-shaft angle was low, 26° and 32°. The outstanding feature of each series of radiographs, whether ending in simple fibrous union or accompanied by necrosis or penetration of the pin, was that there was a little shift at the fracture site in early radiographs. This shift is so often, in the early views, the cause of, and later the evidence of, fibrous union.

4. Pin Penetration (5·3 per cent).—This complication occurred in 4 cases, in 3 in which union was never definitely bony, and in 1 in which the pin was

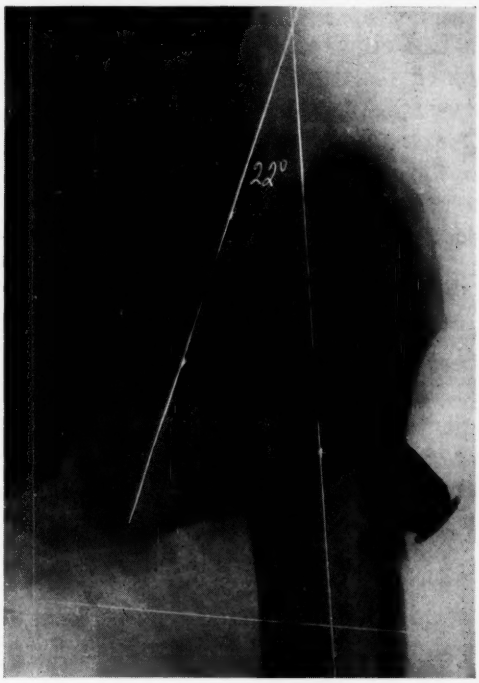

FIG. 133.—*Case* 52, S. E. Fracture-shaft angle very low. Reduction very poor.

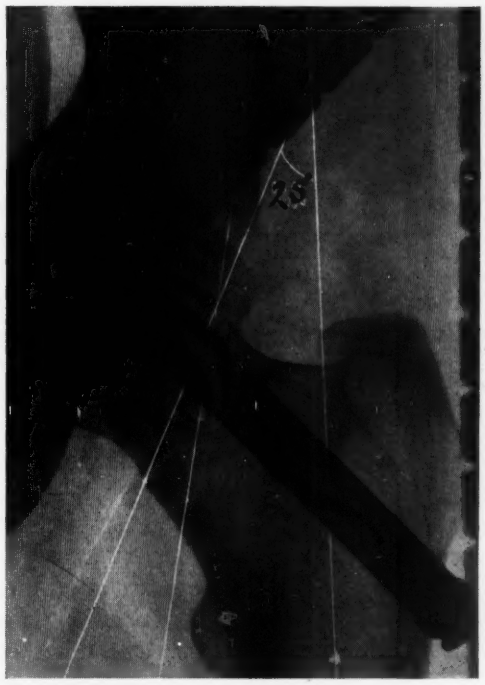

FIG. 134.—*Case* 53, M. C. Fracture-shaft angle very low. In this case the fracture is irregular below and two readings are possible, 12° and 25°. This occurrence was seen in no other case.

FIG. 135.—*Case* 54, P. F. Pin badly placed and has no grip in the head.

FIG. 136.—*Case* 55, M. P. Very poor reduction. Fragments separated.

originally inserted too deeply so as to encroach on the hip-joint. In this latter the pin was removed at 5 months, after bony union had occurred. In two of the other three, union has remained fibrous in nature and the neck has become absorbed, and in the fourth the head has undergone extensive necrosis and collapse, which has resulted in gross penetration of the pin (*Case* 41, *Fig.* 130). With the exception of the case where the pin initially penetrated the joint, it is to be noted that pin penetration only occurred to complicate an existing complication, in two cases fibrous union, and in one necrosis of the head.

5. Cases of Suppuration (4 per cent).—There were 3 cases in which an abscess appeared in the first, third, and sixth week respectively. In the latter two, it was clearly the result of an infected hæmatoma and demands a greater effort at hæmostasis in these deep wounds. Each case was a complete failure in every sense of the word. Two subsequently died, and one survives—a cripple with sinuses. These are old, often debilitated, patients, but it remains a serious indictment that sepsis should have supervened in 4 per cent of the cases.

6. Mortality (5·3 per cent).—The mortality from this operation is low, in spite of the absence of almost any selection, a fact demonstrated by 58 of the cases occurring in 2 years (September, 1937, to September, 1939).

The earliest post-operative death was on the tenth day, from pulmonary embolism. Our mortality for this operation within three months was 5·3 per cent, or 4 deaths in 75 cases. One other case died within three months, but as this occurred three weeks after the severe operation of open reduction and re-pinning, and six weeks after the closed pinning, it is fair to exclude it from the mortality figures.

7. Results not Ascertained.—

a. Untraced. There are 2 cases in which all attempts to locate their whereabouts proved unavailing.

b. Doubtful Cases. Here there are 6 cases; 5 of these died after periods varying from $4\frac{1}{2}$ to 25 months after the operation. Those that did not live out the year could not be claimed as successes, but they were not manifest failures.

For information of all these we relied upon the replies to a questionnaire sent out to close relatives, but we have not felt justified in placing them in any of the classifications mentioned.

There is 1 additional case living at a considerable distance in which the reply to the questionnaire provided insufficient evidence.

Treatment of Failures.—When necrosis of the head was diagnosed, removal of the pin was carried out, or at least strongly advocated. One case was treated by two bone-grafts, otherwise conservative treatment with a calliper or Trumble splint has been employed.

Failed pinnings were usually treated by a subtrochanteric osteotomy of the McMurray or Schanz type.

Conclusions.—

1. The fracture occurred in the middle third of the neck in 97 per cent of the cases—usually lying more or less obliquely.

2. Necrosis is commoner in youth; presumably the capital fragment is very frequently almost completely deprived of its blood-supply, and the dense bone in youth hinders revascularization.

3. Moderate delay in operation leads to no poor results. It is not a very important factor.

4. Early weight-bearing—one case of severe necrosis resulted in a lad of 17. Four successful cases occurred in people over 35 years with very high fracture-shaft angles.

5. The Smith-Petersen pin has been an outstanding success, because it immobilizes the fracture more effectively than any previous device; hence all factors predisposing to movement at the fracture site tend to produce non-union and complications.

These factors are:—

a. A low fracture-shaft angle, increasing the shearing force on the fracture.

b. Poor reduction.

c. Absence of impaction.

d. Faults in placing the pin.

The importance of the fracture-shaft angle is amply borne out by the findings in this series of 75 cases, and clearly demonstrates that the end-result is controlled to an almost equal extent by the nature of the fracture as by the surgeon and his pin.

We feel that a case with an angle below 30° should not be treated by a Smith-Petersen pin alone, and that the addition of a fibular bone-graft might provide the simplest method of assisting union and revascularization and at the same time supplementing fixation, without greatly increasing the post-operative risks.

The technical faults frequently lead to no complication when the fracture-shaft angle is large, but reveal their importance when the angle is small. Similarly, early weight-bearing has led to no bad result in cases over 35 years of age with high fracture-shaft angles.

e. Successful cases have a range of movements of 80 to 100 per cent.

f. Signs of necrosis in the radiograph may be seen as early as 2 months, or be absent as late as 7 months. In 45 per cent of the cases, bony union had occurred.

Collapse of the necrotic head—depends on weight-bearing. The joint space was reduced in one case with massive necrosis and led to a fibrous ankylosis. Otherwise the joint space was largely unreduced although distorted. This lends support to an optimistic approach to cases of necrosis without collapse, where continued absence of weight-bearing and the introduction of a bone-graft to assist revascularization should extend some hope of success.

g. Cases of failed pinning comprise largely technical faults in cases with low fracture-neck angles.

h. Fibrous union is often not so easily explained, but there is usually some evidence of early slipping at the fracture site.

i. Minor degrees of necrosis appear to complicate most cases where union is absent or fibrous; the relationship of these complications is intimate.

j. Penetration of the pin into the joint space complicates fibrous union and necrosis, but never spoils an otherwise successful result, unless the pin is initially penetrating the articular cartilage.

k. The mortality of the Hey Groves operation in this series is 5·3 per cent within three months.

Table I.—Particulars of 75 Consecutive Cases of Fractured Neck of

Case No.	Initials	Age	Fracture-shaft Angle	Day of Operation	Reduction	Pin Position
1	C. B.	59	44°	4	Good	Good
2	E. Ba.	72	53°	3	Good	Good
3	A. Ba.	67	52°	9	Good	Good
4	E. Bl.	60	19°	7	Good; some valgus	Good
5	F. B.	77	48°	2	Good	Good
6	I. B.	73	43°	4	Fair	Fair
7	B. D.	63	35°	5	Good	High
8	S. G.	78	34°	9	Good	Good
9	M. A. Ho.	59	54°	2	Fair	Good
10	M. Hl.	56	43°	6	Good	Good
11	M. Hr.	67	33°	5	? Good	? Good (No lateral)
12	D. J.	14	39°	12	Good	Good
13	M. J.	43	—	5	Good	Good
14	E. H.	13	32°	5	Good	Good
15	W. K.	57	35°	7	Good	Good
16	B. L.	61	33°	7	Good	Good
17	F. L.	67	34°	29	Good; slight valgus	Good
18	F. M.	61	42°	41	None; left in valgus	Good
19	B. P.	50	46°	7	Good	Good
20	R. R.	57	40°	5	Good	Good; short pin
21	A. S.	65	50°	5	Good	High
22	E. S.	65	34°	1	Good	Good
23	H. S.	48	44°	7	Good	Good
24	P. W.	76	36°	13	Good	Good
25	S. E.	53	26°	33	Good	Good

FEMUR TREATED BY THE BRISTOL ROYAL INFIRMARY FRACTURE SERVICE.

INTERVAL WITHOUT WEIGHT-BEARING	INTERVAL BETWEEN OPERATION AND FOLLOW-UP	COMPLAINTS	MOVEMENT	FOLLOW-UP AND RADIOGRAPHS	RESULT
1 day	Months 14	None	100 per cent	Normal anatomy	Success
12 weeks	13	None	100 per cent	Normal	Success
15 weeks	14	None	100 per cent	Normal	Success
10 weeks	13	None	100 per cent	Normal	Success
12 weeks	19	None	90 per cent	Normal	Success
—	42	None	75 per cent	Bony union not perfect position	Success
6 weeks	13	None	80 per cent	Normal	Success
13 weeks	14	Some aching	80 per cent	Normal	Success
28 weeks	18	Occasional aching	80 per cent former range. Old A.P.M.	Bony union; slight varus	Success
4th day	30	None	100 per cent	Normal	Success
6 weeks	24	Occasional aching	100 per cent	Normal	Success
12 weeks	32	None	100 per cent	Normal	Success
7 weeks	17	None	80 per cent. Abduction nil. Pin into acetabular fossa	Normal	Success
13 weeks	12	None	100 per cent	Normal	Success
15 weeks	37	None	90 per cent	Normal	Success
10 weeks	40	None	100 per cent	Normal	Success
12 weeks	12	None	100 per cent	Normal	Success
12 weeks	13	Some aching	80 per cent	Bony union; some valgus	Success
12 weeks	18	None	100 per cent	Normal	Success
18 weeks	43	None	90 per cent	Normal	Success
7 weeks	14	None	100 per cent	Normal	Success
14 weeks	14	Occasional pain; walks well	95 per cent	Normal	Success
Walked same day	12	Some aching; no hard work	95 per cent	Normal	Success
12 weeks	21	None	100 per cent. Abduction 25 per cent. Internal rotation nil	Bony union; some coxa vara	Success
16 weeks	12	Pain after walking ¼ mile; slight limp	90 per cent	Normal	Success

Table I.—Particulars of 75 Consecutive Cases of Fractured Neck of

Case No.	Initials	Age	Fracture-shaft Angle	Day of Operation	Reduction	Pin Position
26	G. W.	64	36°	5	Fair	Good
27	H. S.	35	49°	2	Good	Good
28	A. T.	73	30°	7	Good	Good
29	A. Br.	68	36°	9	? Good (No lateral)	? Good; but deep
30	M. J. E.	70	52°	6	Good	Pin short
31	J. H.	77	42°	11	? Good (No lateral)	? Good
32	F. I.	84	32°	6	? Good (No lateral)	? Good
33	H. W.	80	34°	6	Good	Good
34	B. A. G.	62	37°	4	Good	Good
35	E. M.	70	37°	6	Good	Good
36	M. M.	80	36°	2	Good	Good
37	S. P.	58	21°	6	Good; slight valgus	Good
38	E. A. R.	90	50°	6	? Good (No lateral)	? Good
39	R. H.	17	23°	8	Fair; no impaction	Good
40	P. M.	16½	32°	2	Good	Good
41	J. Na.	52	30°	11	Good	Good
42	J. Ne.	56	26°	9	Good	Good
43	E. F.	63	28°	35	Fair	Good

FEMUR TREATED BY THE BRISTOL ROYAL INFIRMARY FRACTURE SERVICE, *contd.*

INTERVAL WITHOUT WEIGHT-BEARING	INTERVAL BETWEEN OPERATION AND FOLLOW-UP	COMPLAINTS	MOVEMENT	FOLLOW-UP AND RADIOGRAPHS	RESULT
8 weeks	Months 12	None	100 per cent	Normal	Success
1 day	13	Occasional ache	90 per cent	Normal	Success
12 weeks	12	None	85 per cent	Normal	Success
12 weeks	30	General rheumatic pains	100 per cent	—	Clinical success
7 weeks	39	Has no pain. Has pernicious anæmia and some S.C.D. of cord	90 per cent	—	Clinical success
—	35	No pain. Has worked. Now too infirm	100 per cent	—	Clinical success
12 weeks	47	None	90 per cent	—	Clinical success
Has not walked	26	Bedridden; senile decay	90 per cent	—	Clinical success
12 weeks	22	No pain. Some general arthritis	Reports full range	—	Questionnaire success
—	Died 22 mths. after operation	No complaints; full housework; walks over a mile	—	—	Questionnaire success
12 weeks	Died 22 mths. after operation	Occasionally hip troubled her	—	—	Questionnaire success
10 weeks	20	Full housework; walks 2 miles; aches after sitting	"Not full range"	—	Questionnaire success
—	Died after 21 mths.	No complaints; walked a little; 90 years	Full movements reported	—	Questionnaire success
7 weeks	21	None. General duties, R.A.F.	85 per cent	Bony union; necrosis of epiphysis and metaphysis	Bony union; necrosis
1 day	16	No pain; stiffness after long walks; cycles long distances	Fixed adduction. Rotation 20 per cent. Flexion 90 per cent	Bony union; necrosis and collapse	Bony union; necrosis
8 weeks	29	Pain and stiffness; limited activities	Flexion 60 per cent; others 0–10 per cent	Bony union; necrosis and collapse	Bony union; necrosis
12 weeks	16	Limp, pain; limited activities	Flexion *only* 80 per cent	Bony union; necrosis and collapse	Bony union; necrosis
16 weeks	15	Pain + +; stiffness	Flexion *only* 50 per cent	Bony union; necrosis and collapse	Bony union; necrosis

Table I.—Particulars of 75 Consecutive Cases of Fractured Neck of

Case No.	Initials	Age	Fracture-shaft Angle	Day of Operation	Reduction	Pin Position
44	M. B.	62	31°	4	Fair	Good
45	W. H.	46	37°	15	? Good	Poor (No lateral)
46	M. S.	62	28°	2	Fair +	Fair; short
47	C. W.	26	19°	8	Fair; separated	Good; no impaction
48	A. H. O.	71	26°	6	? Good	? Good (No lateral)
49	E. B.	71	29°	2	? Good	? Good (No lateral)
50	E. R.	65	32°	10	Good	V. posterior
51	E. F.	46	8°	5	Good	Posterior; little hold in head
52	S. E.	81	22°	1	Very poor	? No lateral
53	M. Cu.	61	25°	8	Good	Good, but too short
54	P. F.	72	37°	10	Good	Too short and too low
55	M. P.	80	30°	4	Good, but separated	Poor, not into head
56	C. B.	76	26°	5	Good	? Good. No lateral
57	M. W.	67	32°	5	Good	Good
58	H. M.	67	24°	4	Fair	Good
59	G. H.	70	24°	12	Good	Good

FEMUR TREATED BY THE BRISTOL ROYAL INFIRMARY FRACTURE SERVICE, *contd.*

INTERVAL WITHOUT WEIGHT-BEARING	INTERVAL BETWEEN OPERATION AND FOLLOW-UP	COMPLAINTS	MOVEMENT	FOLLOW-UP AND RADIOGRAPHS	RESULT
	Months				
14 weeks	24	Pain; walks with difficulty	Flexion *only* 30 per cent	Fibrous union; collapse of head; pin penetration	Fibrous union; necrosis
8 weeks	17	Pain; walks with crutches	Flexion *only* 10 per cent	Fibrous union; necrosis and collapse	Fibrous union; necrosis
24 weeks	42	Does own housework; aches; walks a mile with a stick	50 per cent	Collapse of neck. Head necrosed, but round	Fibrous union; necrosis
No weight-bearing osteotomy	24	Limited movements after Schanz osteotomy	—	Massive necrosis. Osteotomy, great loss of cartilage	Non-union; necrosis
14 weeks	Died after 14 mths., 15 mths. ago	No pain; walked with crutches	—	Fibrous union; necrosis	Fibrous union; necrosis
8 weeks	37	Pain; maximum walks 30 yds.	30 per cent	Fibrous union; necrosis	Fibrous union; necrosis
6 weeks	13	Schanz osteotomy for failed pinning	Limited	Pin had slipped right out	Failed pinning
10 weeks	21	McMurray osteotomy for failed pinning	Limited	Pin slipped out; McMurray osteotomy	Failed pinning
? walked at all	Complete failure within 6 mths.	Non-union; pin removed after 6 mths.	—	Non-union	Failed pinning
12 weeks	30	McMurray osteotomy for failed pinning	50 per cent	Pin slipped out; McMurray osteotomy	Failed pinning
—	Died after 6 mths., 27 mths. ago	McMurray osteotomy for failed pinning	—	Pin slipped out; McMurray osteotomy	Failed pinning
—	Died after 6 wks., 33 mths. ago	Open reduction and re-pinning. Died 3 weeks later	—	Failed pinning	Failed pinning
4 weeks	32	Uses crutch and stick; some pain	50 per cent	Fibrous union; great trochanter up	Fibrous union
18 weeks	12	Pain and limp	40 per cent	Fibrous union	Fibrous union
12 weeks	16	Pain; walks very little; old and infirm	30 per cent	Fibrous union; pin penetration	Fibrous union; pin penetrating hip
—	27	Some aching; limited movements; very active	40 per cent	Fibrous union; pin penetration	Fibrous union; pin penetrating hip

Table I.—Particulars of 75 Consecutive Cases of Fractured Neck of

Case No.	Initials	Age	Fracture-shaft Angle	Day of Operation	Reduction	Pin Position
60	A. H.	39	28°	2	Good	Good, but too deep
61	S. J. B.	73	33°	11	Good	? Good. No lateral
62	S. P.	69	33°	2	Good	Good
63	A. W.	56	41°	9	Good	Good
64	M. Ca.	66	30°	1	Good	Good
65	K. Be.	69	—	2	X-rays lost	—
66	H. L. W.	76	37°	2	Good	Good
67	S. T.	75	34°	4	Good	Fair; too low
68	E. J.	71	31°	2	Good	Good
69	L. K.	57	30°	5	Good	Poor
70	A. Be.	67	29°	4	Good	Good
71	W. B.	52	52°	4	? Good	? Good (No lateral)
72	E. C.	74	43°	2	Good	Good
73	F. M.	63	32°	12	? Good	? Good (No lateral)
74	E. P.	88	27°	2	? Good	? Good (No lateral)
75	M. H.	77	26°	12	Good	Good

FEMUR TREATED BY THE BRISTOL ROYAL INFIRMARY FRACTURE SERVICE, *contd.*

INTERVAL WITHOUT WEIGHT-BEARING	INTERVAL BETWEEN OPERATION AND FOLLOW-UP	COMPLAINTS	MOVEMENT	FOLLOW-UP AND RADIOGRAPHS	RESULT
12 weeks	Months 26	Some pain; has disseminated sclerosis	50 per cent	Bony union; pin penetrated; arthritis	Bony union; pin penetrating hip
—	Died after 11 mths., 10 mths. ago	Large sinus; after 8 weeks died	—	—	Suppuration; non-union
—	Died after 5 mths., 13 mths. ago	Discharged; operation; since died	—	—	Suppuration; non-union
—	19	Sinuses; bedridden	Very limited	—	Suppuration; non-union
—	15 mths. since operation	Died of pulmonary embolism on 10th day	—	—	Died
—	44	Died of bronchopneumonia in 4th week	—	—	Died
—	21	Died of cerebral thrombosis after 2½ mths.	—	—	Died
—	13	Died of general debility and bedsores after 3 mths.	—	—	Died
—	—	—	—	—	Untraced
—	—	—	—	—	Untraced
—	30	Died after 7½ mths. from pneumonia. Housework; stick out of doors; occasional pain	—	—	Results not ascertainable
7 weeks	Died after 25 mths., 12 mths. ago	Pain; walked without stick. At work	Limited range	? Success	Results not ascertainable
—	Died after 11 mths., 18 mths. ago	Rarely had pain; never got up; too infirm	—	—	Results not ascertainable
32 weeks	Died after 18 mths., 24 mths. ago	Pain always after use; light housework walked with stick	Fair	—	Results not ascertainable
13 weeks	Died after 4 mths., 24 mths. ago	Some pain; walked with chair to bed; very frail	Good	—	Results not ascertainable
16 weeks	14	Walks 100 yd. with two sticks; no housework; pain only after jerk	Full	? Success	Results not ascertainable

SUMMARY

This paper pays a tribute to the ingenuity, simplicity, and safety of the Hey Groves method of introducing the Smith-Petersen pin, and outlines the technique employed at the Bristol Royal Infirmary Fracture Service, as worked out by one of us (K. H. P.).

The first 75 consecutive cases have been followed up and analysed (A. L. E.-B.).

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TUMOURS OF THE SMALL INTESTINE

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For the area exposed, the small intestine enjoys as great an immunity from new growth as any part of the body. This is the more remarkable in that it follows the stomach and precedes the colon, which together are the seat of over 40 per cent of all malignant growths. No adequate explanation has yet been forthcoming. For this and other reasons the tumours of this region are of considerable interest.

The biopsy and autopsy material of the past ten years in the Department of Pathology has been studied in conjunction with the clinical records. Material from 13,139 patients has been reviewed and, excluding heterotopic nodules, 21 primary tumours have been discovered (*Table I*). No such material can be sufficiently non-selected to give any adequate idea of the incidence. In the 2434 autopsies during this period there were 1 leiomyoma, 1 lipoma, 1 adenoma, 1 argentaffinoma, and 2 undoubted primary malignant growths—a lymphosarcoma of the duodenum and a carcinoma of the jejunum. Eight benign tumours of the small intestine, 1 argentaffinoma, 2 carcinomata, and 2 sarcomata were obtained from the Royal Victoria Hospital. In the clinical records of this hospital during the same period there are notes of 541 gastric and 760 colonic and rectal neoplasms; 42 and 44 per cent of these were subjected to operation.

The incidence of malignant tumours of the small intestine has been frequently discussed. It has varied considerably in the small series reported, but the figure of 7 per cent of all intestinal cancers outside the stomach, or 0·5 per cent of all fatal neoplasms, suggested by Ewing (1940), is probably too high. At the Mayo Clinic the number of carcinomata recorded up to 1936 was 76. This represented in different 10-year periods an incidence of 0·47 to 0·62 per cent of all carcinomata of the gastro-intestinal tract. These cases were reported by Rankin and Mayo (1930), Plunkett, Foley, and Snell (1936), and Mayo and Nettrour (1937). Other reports are rarely concerned with more than one or two cases and a review of the literature. Representative papers are those of Jefferson (1916), Schofield (1930), Cave (1932), Lynch (1933), Barnhart (1933), Ackman (1935), Carter (1935), Harries and Harrison (1935), Wheeler (1938), Cameron (1938), Withers (1938), and Heggs (1939). Nickerson and Williams (1937) reported 8 carcinomata in 11,206 autopsies over a 40-year period. In the recent literature the incidence of sarcomata is slightly less than that of carcinomata (Cameron, 1938). Benign tumours have been less frequently reported and were about one-half as frequent as carcinomata in the Mayo Clinic operation records (Rankin and Newel, 1933). In the autopsy material reviewed by Raiford (1932) they were the most frequent, in the ratio of 37 to 18.

HETEROTOPIA

Heterotopic masses are not true neoplasms, but are composed of tissue displaced during development which would be normal if it occurred at another site. A slight irregularity of arrangement or some disproportion in the different elements

Table I.—DETAILS OF 21 TUMOURS OF THE SMALL INTESTINE

CASE NO.	AGE AND SEX	NATURE OF TUMOUR	CLINICAL FINDINGS	SITE	PATHOLOGICAL REMARKS
1	28 yr. M.	Lipoma	Acute obstruction 2 days	3 ft. ileocæcal valve	Intussusception
2	55 yr. M.	Lipoma	Abdominal pain 9 mths. Acute symptoms 2 days. Palpable tumour	12 in. ileocæcal valve	Intussusception
3	58 yr. F.	Lipomata	Chronic obstruction 3 mths.	Terminal ileum	Multiple: 1 large—cæcum 4 small—ileum
4	58 yr. F.	Lipoma	Abdominal pain 3 wks. Palpable tumour in R.I.F.	Ileocæcal valve	Pedunculated; infected
5	68 yr. F.	Lipoma	Died, adenocarcinoma of cæcum	Ileocæcal valve	Pedunculated
6	41 yr. F.	Adenomyoma	Abdominal pain 2 mths.	1st part of duodenum	Mucous glands; no ulceration
7	17 mths.	Adenomyoma	Colic 3 days. Palpable tumour	Ileum	Mucous glands; intussusception
8	3 wks. M.	Adenomyofibroma	Died, gastroenteritis	6 in. duodenojejunal junction	? Derived from pancreatic heterotopia
9	60 yr. M.	Leiomyoma	No symptoms. Died of cerebral hæmorrhage	Ileum	Sessile
10	39 yr. F.	Leiomyoma	Chronic obstruction; acute. Palpable tumour	Terminal ileum	Infected, ulcerated broad pedicle
11	27 yr. M.	Subserous fibroma	Crampy abdominal pain	Antimesenteric border of ileum 7 ft. from valve	Torsion of narrow peduncle
12	50 yr. F.	Argentaffinoma	? Chronic appendix	Terminal ileum	Single; size of pea
13	71 yr. F.	Argentaffinoma	Abdominal discomfort 1 yr.	Ileum and cæcum	Metastases in lymph-nodes
14	71 yr. F.	Adenocarcinoma	Chronic obstruction, 3 mths.; acute. Died	15 in. distal duodenojejunal junction	Annular constricting
15	58 yr. F.	Adenocarcinoma	Chronic obstruction, 6 wks.; acute. Palpable tumour	Lower ileum	Annular constricting
16	50 yr. F.	Adenocarcinoma	Abdominal pain, 3–4 mths.	About jejunoileal junction	Flattened cauliflower type
17	61 yr. M.	Adenocarcinoma	Abdominal pain 1 year. Anæmia	Lower jejunum	Annular constricting
18	65 yr. M.	Lymphosarcoma	Abdominal pain, 10 wks. Some vomiting	4 in. ileocæcal valve	Non-stenosing
19	60 yr. M.	Lymphosarcoma	Mass in left flank. Perforation	12 in. duodenojejunal junction	Saccular dilatation with ulceration
20	20 yr. M.	Lymphosarcoma	Frequent attacks colic	Lower third ileum	Stenosing
21	57 yr. M.	Lymphosarcoma	Cough, 4 mths. X rays, "lung tumour"	2nd part of duodenum	Non-stenosing: Secondaries in lungs

will often be found. These tumours are usually small, but are of interest as they simulate neoplasms and may encourage unnecessary or too extensive surgery.

In three patients, aged respectively 21, 36, and 56 years, nodules about the size of a pea were present in the duodenum, in one case in the wall of a small diverticulum in the first part of the duodenum. These patients were explored for vague abdominal pains not entirely typical of peptic ulceration, and associated and probably more significant pathology included a duodenal ulcer and a gall-bladder lesion. Histologically the nodules were composed of pancreatic acini, a few islands of Langerhans, and ducts, which in one case greatly predominated (*Fig.* 137).

FIG. 137.—Pancreatic heterotopia in duodenal wall, showing pancreatic acini, some pancreatic ducts, and Brunner's glands. (× 45.)

They lay in the submucosa and extended into the muscle wall and had not produced ulceration. In another specimen, pancreatic, but no other heterotopic tissue, was found in the wall of a large Meckel's diverticulum in a man, aged 26 years, who complained of abdominal pain and fullness after meals and showed a small residue of barium in the stomach after 6 hours. No other abnormality was found in this patient. Six other Meckel's diverticula have been examined. Two contained islets of peptic and Brunner's glands and one gastric glands only. None showed evidence of ulceration. Though associated pathology was rarely found, there was no convincing evidence of any relationship between the clinical symptoms and this heterotopic tissue. Only one patient appears to have passed blood by the rectum, and her diverticulum showed no ulceration and no heterotopic tissue.

Danzis (1938) states that 328 cases of aberrant pancreatic tissue and 44 of annular pancreas have been described in the stomach and intestine. He added two cases. In his first a small and hard cauliflower-like mass in the first part of the duodenum was unfortunately regarded as malignant and treated by a radical operation, with death of the patient. Greenblatt, Pund, and Chaney (1936) have

reviewed the theories held to account for heterotopia. They strongly advocate removal of a Meckel's diverticulum found at operation. Womack and Siegert (1938) report perforation of 6 Meckel's diverticula containing ectopic gastric mucosa. They state that only in 15 reported cases has pancreatic tissue been discovered in the wall of a Meckel's diverticulum.

SIMPLE TUMOURS

These are not common. Rankin and Newell (1933) reported 35 cases from the Mayo Clinic, and Raiford (1932) found 37 benign tumours in 11,500 autopsies and 13 in 45,000 surgical biopsies. Five lipomata, 3 adenomata, 2 leiomyomata, and a pedunculated subserous fibroma are available, and illustrate many of the diagnostic problems and the fact that the size and site of a simple tumour are more important than its nature.

Lipomata.—Two of these produced intussusceptions (*Cases* 1 and 2). The other three occurred almost at the ileocæcal valve. One (*Case* 3) was multiple and was associated with œdema and non-specific inflammatory changes in the wall of the terminal ileum and cæcum, another (*Case* 4) was pedunculated and heavily infected, and one (*Case* 5) appeared to be an incidental finding in a carcinoma of the cæcum.

Case 1.—A male, aged 28 years, had been perfectly healthy except for an attack one year ago of severe pain around the umbilical region lasting for several days and associated with vomiting. The morning of the day before admission a severe attack of crampy pain in the umbilical region commenced, and continued until the next day, when the pain moved into the left lower abdomen. It was associated with severe and continued vomiting and with absolute constipation. On examination the abdomen moved freely on respiration and was most tender in the right iliac fossa, where there was slight rigidity. No mass could be felt. At operation an intussusception extending to within 18 in. of the ileocæcal valve was discovered.

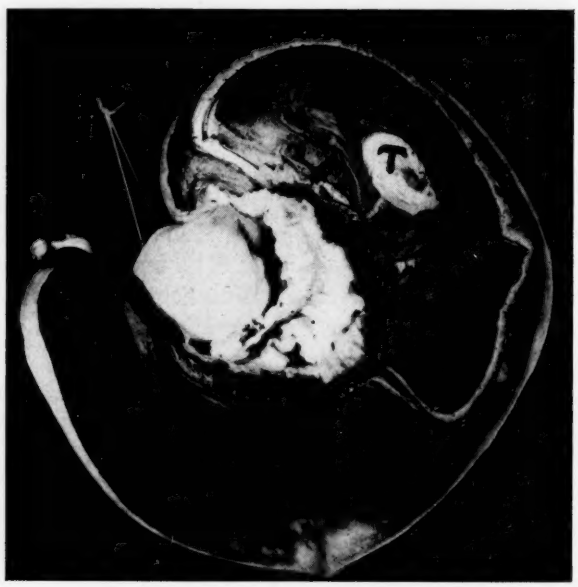


FIG. 138.—Intussusception due to a submucous lipoma (T) situated towards the proximal end of the intussusceptum.

It was resected. On sectioning after fixation a tumour about the size of a walnut was found hanging into the lumen of the intussuscepted bowel not far from the point of entrance (*Fig.* 138). This proved to be a simple submucous lipoma.

Case 2.—A man, aged 55 years, gave a nine months' history of intermittent attacks of crampy abdominal pain associated with attacks of vomiting and thought to be relieved by powders. He had diarrhœa at intervals, followed by constipation. During the week previous to admission the pain had become almost continuous and for the last two days was most severe on the right side and radiated into the back. Two days before admission he had diarrhœa and noticed bright red blood mixed with the motion. After this he passed only some flatus, but vomited incessantly. On examination the abdomen was held rather tense. During paroxysms of pain it was possible to feel a mass which appeared to be in the position of the transverse colon. At operation there was an intussusception of the small bowel into the large for about 12 in. When this was reduced a rounded tumour, arising about 12 in. from the ileocæcal valve, was found almost to fill the lumen. A resection with end-to-end anastomosis was entirely successful. The tumour was a lipoma. The fat cells resembled those of adult fat. The mucosa overlying it was greatly congested and œdematous, but only moderately inflamed.

Case 3.—A woman of 58 years of age gave a three months' history of intermittent crampy abdominal pain not definitely influenced by food and associated recently with occasional vomiting and diarrhœa. A barium meal had all reached the cæcum and ascending colon within six hours. At operation the ileocæcal valve was almost occluded by a lipoma the size of a hazel-nut situated just inside the cæcum. There were four smaller lipomata in the ileum. A right colectomy with anastomosis was successfully performed.

Case 4.—A female, aged 58 years, complained of intermittent spasms of colicky pain in the right lower abdomen and of a constant dull ache in the right iliac fossa for the previous three weeks. The pain was severe during a movement of the bowels, but relief followed this. On one occasion she passed blood and pus, with temporary relief. There was no vomiting. On examination she was anæmic, with a hæmoglobin of 50 per cent. There was a palpable tumour about the size of a tangerine orange in the right iliac fossa; later this tumour became smaller. It was tender but freely movable. The cæcal filling was irregular with both a barium meal and a barium enema. A right colectomy with side-to-side iso-peristaltic anastomosis was performed. A polyp about the size of a raisin hung by a stalk into the cæcum from the ileocæcal valve. This was constricted, and admitted only a small probe. Histologically, the epithelium covering the polyp was lost; some fat cells could be distinguished, but the tumour was heavily infected and consisted largely of recent granulation tissue. There was considerable subacute and non-specific inflammatory change in the submucosa around the ileocæcal valve. The patient developed bronchopneumonia and died. No other lesions were found at autopsy.

Comment.—This case is of interest as the passage of blood and pus and the fibrosis in the region of the ileocæcal valve suggests that other polypi may have existed there, and, becoming heavily infected and traumatized, may have broken away. The possibility of a spontaneously reduced intussusception may also be considered, but the ileum could scarcely have passed through the narrowed ileocæcal valve.

Rankin and Newell (1933) found 2 lipomata in 35 benign neoplasms of the small intestine treated surgically. Comfort, in 1931, reviewed lipomata of the gastro-intestinal tract. He added 9 found in the small intestine at autopsy and 1 removed surgically at the Mayo Clinic. These, with the reports in the literature, gave 65 lipomata in the small intestine and 181 in the entire gastro-intestinal tract. Intussusception had then been described in 26 cases in the small intestine.

Adenomata.—In 3 patients adenomata were found. One (*Case* 6) occurred in a woman of 41 years of age who was explored for upper abdominal pain of two months' duration not definitely related to food. Four years previously she had vomited blood and passed tarry stools. The tumour was about the size of an almond

and was removed from the usual site of an ulcer in the first part of the duodenum. Another (*Case* 7) occurred in the ileum of a boy of 17 months, and had initiated an intussusception. Both of these were typical adenomyomata and the epithelial lining cells were mucin-producing. No example of the rarer form arising in Brunner's glands was found.

A third example (*Case* 8) occurred in a three weeks' old male infant who died of gastro-enteritis. It projected from the antimesenteric border of the bowel as a pea-sized nodule lying beneath the serosa 6 in. distal to the duodenojejunal junction. Histologically, it showed duct-like acini in all stages of development, and growing in relation to fibrous tissue elements which in some areas appeared almost myxomatous. The cells produced no mucin and showed transitions to deeply stained cells lining small acinar-like spaces resembling pancreatic tissue. Without raising the question of the origin of tumours from misplaced or heterotopic tissue, it may be suggested that this adenoma, situated in great part outside the muscle coats of the bowel, represented a disorganized overgrowth of misplaced tissue organizers similar to those which in the proper environment produced the pancreas.

There is little doubt that the minute polypi resulting from glandular hyperplasia and constituting 9 of the 13 examples reported by Saint (1927) are often overlooked, and it is difficult to regard them as true tumours, or of any great significance.

Leiomyomata.—One example was found in a woman of 60 years of age who died of a cerebral thrombosis. It was sessile, did not occlude the lumen, and originated from the circular muscle of the bowel wall (*Case* 9).

Case 10.—A woman of 39 years of age gave a history of intermittent but severe crampy pain in the umbilical region for four or five months. A barium meal six weeks before admission showed only moderate ileal stasis. The pain was frequent and almost continuous for the two weeks before admission, and she had vomited during the last two days. Paroxysms of severe pain were almost continuous for nine hours before admission, and there was repeated vomiting and absolute constipation. The patient was well nourished. The abdomen was tender but not rigid, and there was an easily palpable mass occupying the right iliac fossa. At operation a congested and thickened portion of terminal ileum was found. Its serous surface was dulled by a fibrinous exudate. Towards the distal end of this was a palpable mass almost entirely blocking the lumen of the gut and firmly fixed to the antimesenteric aspect of the bowel wall. Histologically the tumour was a leiomyoma, but the surface was ulcerated and there was a considerable pyogenic infection.

Smith (1937) recorded 8 examples of leiomyomata in 36,000 autopsies and reported 1 case associated with hæmorrhage into the gut. He reviewed the 109 cases involving the small intestine recorded in the literature. These tumours may be either 'inner' myomata, projecting into the lumen, or 'outer', projecting into the peritoneal cavity, where they have been reported to reach the size of a man's head. The 'outer' tumours are especially liable to central cystic necrosis and to hæmorrhage which may find its way into the lumen of the bowel.

Fibroma.—Only one example was discovered.

Case 11.—A man, aged 27 years, gave a history of crampy pain in the region of the umbilicus for one day. The pain then settled in the right iliac fossa. There was no vomiting and the pulse and temperature were normal. He had had a similar attack two years previously. There was slight tenderness and very slight rigidity in the right iliac fossa and he had some moist sounds in the chest. Under expectant treatment he improved, but the symptoms returned three days later, and the next morning he had an attack of very severe pain, rolled about in bed, belched up much wind, and vomited a little mucus. The pain was then in the upper abdomen rather than in the iliac fossa. He was explored through a gridiron

incision. The appendix, apart from a slight injection of its larger blood-vessels, was normal. A tumour about the size of a walnut was found about 7 ft. from the ileocæcal junction. The tumour hung free in the peritoneal cavity and was attached by a stalk, half-an-inch long and the thickness of strong cord, to the antimesenteric border of the ileum. This stalk had become twisted and the tumour was deeply congested, its serous surface being dulled by a fibrinous exudate; in many areas it appeared a reddish-black colour. Histologically the tumour was composed of fibrous tissue and collagen. No muscle elements could be identified. The whole showed commencing necrosis: blood had escaped into the tissue spaces, and fibrin was present on the serous surfaces. Inflammatory cells were few, and proliferating connective tissue elements were absent.

Comment.—A pedunculated tumour hanging into the peritoneal cavity is described. It underwent torsion and produced symptoms. By itself such torsion, especially in the antimesenteric wall of the bowel, cannot be regarded as an adequate stimulus for the production of pain. It must have stimulated irregular peristalsis and spasmodic contraction of the gut. The pain thus produced was not sharply localized and was diffusely referred to the umbilical region. The pain and tenderness in the right iliac fossa must have resulted from irritation of the parietal peritoneum by the fibrin on the surface of the strangulated tumour.

In the Mayo Clinic records (Rankin and Newell, 1933) there were 6 fibromata, of which 4 were extraluminal, 2 being pedunculated. No symptoms are recorded.

CARCINOID OR ARGENTAFFIN TUMOURS

It is doubtful if these tumours should be described as malignant. Metastases may be found in the regional lymph-nodes, but cases are recorded where following incomplete removal of metastases the patient has lived for ten or even twenty years (Porter and Whelan, 1939).

The tumours are often described as multiple, but in 29 cases reviewed by Raiford (1933) only 2 were multiple. In a most comprehensive study Feyrter (1934) found tumours composed of argentaffin cells in 1·4 per cent of 2500 autopsies. They were mostly the size of a lentil seed, though 26 per cent were larger than a hazel-nut. In his series 34 of the autopsies yielded the 56 carcinoid tumours.

One argentaffinoma in this series was about the size of a dry pea (*Case* 12). It had invaded the muscle coats of the terminal ileum. Symptoms similar to those of chronic appendicitis were attributed to it. Another case was of greater interest:—

Case 13.—An old lady of 71 years of age experienced intermittent and crampy pains around the umbilical region for one year. There was increasing constipation and she sometimes vomited during an attack of the pain. On examination she was anæmic and slightly wasted. The abdominal walls were lax, and a small fixed tumour was palpated to the right of the umbilicus. There was no visible peristalsis and nothing was discovered per rectum. At operation the terminal ileum was distended and its walls greatly thickened. The cæcum was firmly fixed to the posterior abdominal wall. A side-to-side anastomosis was performed between the ileum and transverse colon. Nineteen days later the patient died. At autopsy the lumen of the terminal half-inch of the ileum would only admit a fine probe. The wall was infiltrated by a whitish growth which had ulcerated on the mucosal surface. In the cæcum there were numerous yellowish-white nodules varying from 1 to 5 mm. in size. The ileum and cæcum with their mesenteries were firmly drawn down to the posterior abdominal wall by thickened fibrous tissue, and microscopically the related lymph-channels and lymph-nodes of the mesenteries showed deposits of the tumour growth. There were no secondaries in the liver or elsewhere. Histologically, the tumour was composed of sheets of relatively uniform cells, rounded or polygonal in shape and with well-defined nuclei showing a coarse arrangement of chromatin (*Figs.* 139, 140). There was no true acinar formation and the growth never resembled an adenocarcinoma. These tumours can be easily recognized with ordinary stains, but by specific methods the intra-cytoplasmic granules reveal their affinity for silver. This example of a metastasizing argentaffinoma has been referred to by Nelson (1939).

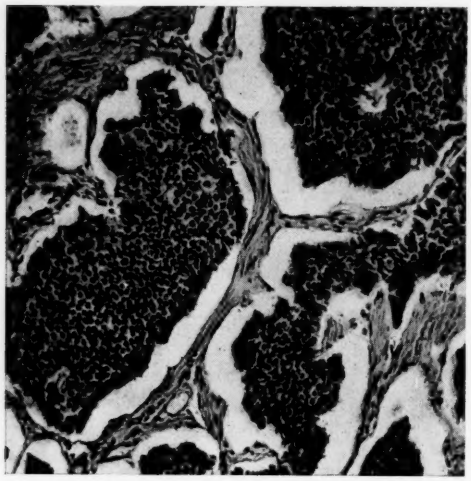


FIG. 139.—*Case* 13. Argentaffin tumour invading wall of ileum. The typical arrangement of the cells and the absence of acinar formation is well seen (hæmatoxylin and eosin). (× 100.)

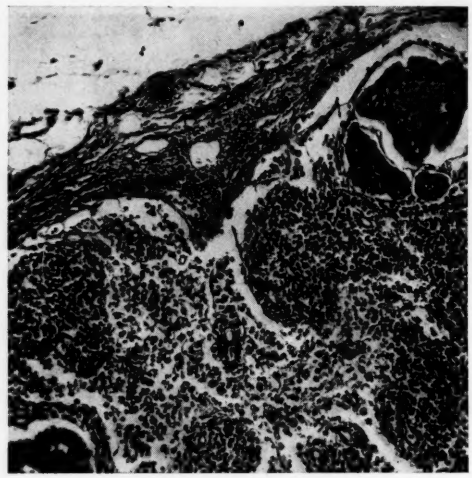


FIG. 140.—Same case. Metastases of argentaffin tumour in mesenteric lymph-gland. (× 125.)

Argentaffin tumours have recently been extensively studied with reference to the silvering reaction of the cytoplasmic granules of their cells of origin (Masson, 1928; Raiford, 1933; Feyrther, 1934; Ariel, 1939; Popoff, 1939; Porter and Whelan, 1939). It is doubtful if this reaction is in any way specific, and though the tumours probably arise from the Nicholas Kultschitzky cells of the mucosa the origin of these is also obscure and the recent work of Masson (1928, 1930) has not completely proved their origin from entoderm associated with neural elements. Their derivation by Raiford (1933) from the migration of cells of neural ectoderm normally forming a part of the general chromaffin system is also not entirely satisfactory.

Porter and Whelan (1939) have attempted to separate those tumours arising in the fibrosed appendix and associated with neuromatous elements or schwannomata, and rarely metastazing, from those occurring outside the appendix and consisting of argentaffin cells and no nerve elements, and showing more tendency to spread. The former are regarded as reactive rather than neoplastic. The literature would suggest that intestinal growths do more often metastasize than those in the appendix.

CARCINOMATA

In the literature of small intestine tumours carcinomata occupy a disproportionately large place. It is not at all clear that some of the older accounts distinguished carcinoid or argentaffin tumours. Many of the cases reported and reviewed appear to have been accepted as *primary* tumours of the small intestine on a very inadequate basis. This is especially so in the duodenum. It is permissible to include tumours of the peri-ampullary duodenal mucosa, but in advanced cases it is quite impossible to decide whether a tumour is primarily of the ampulla or of the peri-ampullary duodenal mucosa. In ampullary growths the clinical and pathological picture is different from that of tumours elsewhere in the small intestine, and no useful purpose is served by considering such tumours along with

others of the small gut. Again the frequent reports of tumours ulcerating the duodenum and extending into the pancreas suggests that many of these tumours are primarily pancreatic. The pancreas is very rarely invaded by neighbouring neoplasms. Primary pancreatic carcinomata are not uncommon and readily invade adjoining tissues. The most clear-cut evidence of primary duodenal involvement should be forthcoming before a growth involving only a part of the circumference of the duodenum and invading the pancreas is described as of duodenal origin. Making all allowances, the literature does suggest that for the area at risk the highest incidence of carcinomata of the small intestine is in the duodenum.

In this series 4 patients presented conclusive evidence that the growth primarily involved the small intestine. The examples occurred in the upper and lower jejunum, about the jejuno-ileal junction and a few feet from the ileocæcal valve. Two were in men and two in women, and the ages ranged from 50 to 71 years. Three were operated on, and after resection of the gut were alive and well 6 months, 2½ years, and 7 years later.

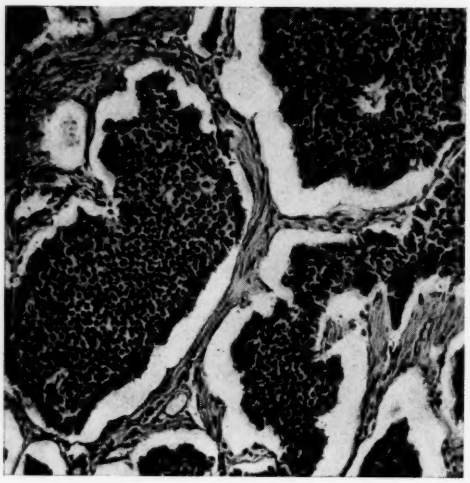
Case 14.—A woman of 71 years of age was admitted complaining of increasing severe and frequent vomiting for the previous two or three months. The vomiting was worse in the evenings, but was not definitely related to food and there was remarkably little pain. Long-standing constipation had become obstinate, but recently there had been several attacks of diarrhœa. She was poorly nourished and anæmic and the skin was dry. The abdomen was prominent, but there was no tenderness or rigidity. The vomiting became progressively more severe and uncontrollable. There was no absolute constipation. She died five days later.

At autopsy the stomach was enormously dilated and seemed to fill the greater part of the peritoneal cavity. Its walls were thin and it contained a very large quantity of turbid and bile-stained fluid resembling that found in acute dilatation of the stomach. The dilatation ended about 15 in. below the duodeno-jejunal flexure where there was a ring-like constriction encircling the bowel (*Fig.* 141). The lumen at this point was almost completely obliterated and only a very fine and flexible probe could be passed. Below this the bowel was normal and appeared very empty.

Microscopically, all the coats of the bowels were invaded by tumour cells maintaining an adenomatous arrangement but secreting no mucin. The stroma was fibrous and had produced constriction. There was moderate hypertrophy of the wall of the bowel above the tumour. A careful naked-eye and microscopical examination failed to show any secondary tumour deposits either in the drainage lymph-glands or in the liver.

FIG. 141.—Annular carcinoma constricting jejunum, with dilatation above growth (*Case* 14).

Clinical records of the other three cases (*Cases* 15, 16, and 17) suggest that intermittent crampy pain, umbilical or sub-umbilical in character, is experienced sometimes for almost a year. Vomiting with some nausea follows, but the onset of severe vomiting indicates progressive and complete obstruction only in the lower reaches of the intestine. Carter (1935) regards vomiting as the most characteristic symptom of tumours of the upper jejunum and pain as infrequent. This was so in *Case* 14.



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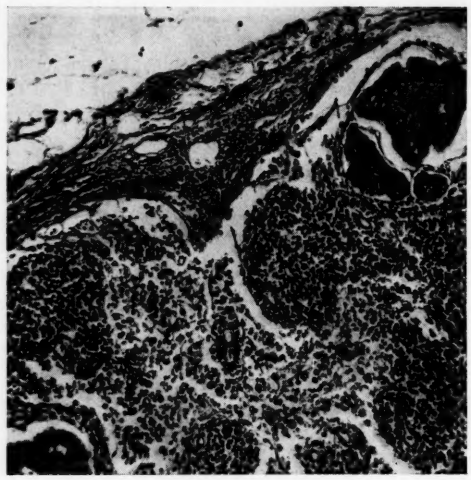

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LYMPHOSARCOMATA

By far the greatest number of malignant non-epithelial tumours of the small intestine arise from tissue potentially capable of producing lymphocytes. In not a few cases the morphological resemblance between the tumour cells and either lymphocytes or lymphoblasts is slight and the commonly used name 'lymphosarcoma' may be open to some objection. The term 'reticulum-cell sarcoma', to include all malignant tumours arising from reticulum or its lymphoid derivatives, may be preferred. The transitions in cell type even in a single tumour make it difficult to limit this term to those tumours with large cells and nuclear structure resembling the original reticulum cells, and no practical purpose is served by much morphological subdivision. The terminology is discussed and the reports of over 375 cases in the large and small intestine are reviewed in the papers by Corner and Fairbanks (1905), Graves (1919), Ullman and Abeshouse (1932). Corresponding roughly to the area at risk, the incidence is about twice as high in the small as in the large intestine. None of these cases appear to terminate as a lymphatic leukæmia and the condition is to be distinguished from a generalized lymphadenopathy. Spread beyond the regional lymph-nodes is usually by the blood-stream.

Leiomyosarcomata are extremely rare and Anderson and Doob (1933), reporting 1 case, accept 18 other examples in the literature. No examples have been seen.

The lumen of the gut at the site of a lymphosarcoma may be unaltered or even dilated owing to infiltration of the wall by tumour cells and to a relatively scant production of fibrous tissue stroma. But even in these cases functional paralysis of a short segment of the bowel and possibly irregular spasm in neighbouring portions may produce symptoms which suggest obstruction, such as intermittent crampy abdominal pain and attacks of vomiting. *Case* 18 illustrates this: There was no infiltration of the mesentery and the patient was alive and well 15 months later. In *Case* 19 the dilatation was much more marked, and though the lesion was high up

FIG. 142.—Lymphosarcoma of jejunum infiltrating wall and producing a saccular dilatation (*Case* 19).

in the intestine no clear symptoms of obstruction developed. The symptoms were probably due to involvement of nerves in the mesentery by the extension of the tumour, to irritation of the parietal peritoneum, and a localized peritonitis.

Case 19.—A previously healthy man, aged 60 years, suddenly developed pain in the left side of the abdomen two months before operation. It had no definite relationship to food. A large lump was easily felt in the left flank. A barium meal revealed nothing, and while awaiting exploration as a colonic growth or diverticulitis the patient developed the symptoms of a

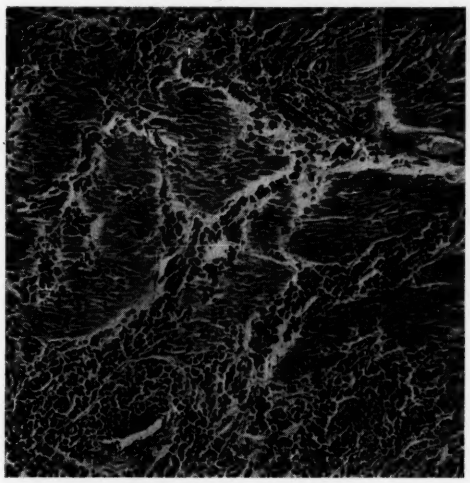

FIG. 143.—*Case* 19. Lymphosarcoma invading muscle coats of jejunum. The tumour is producing very little stroma. (× 125.)

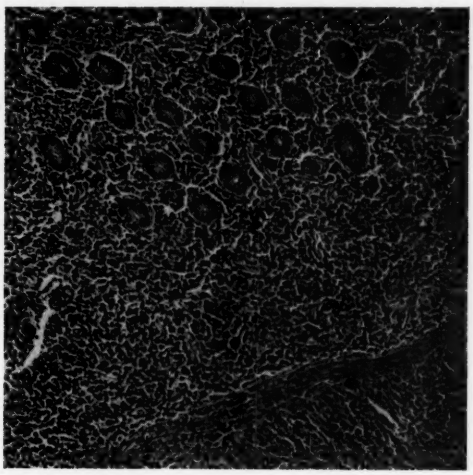

FIG. 144.—Same case. Lymphosarcoma infiltrating submucous tissue of jejunum. (× 125.)

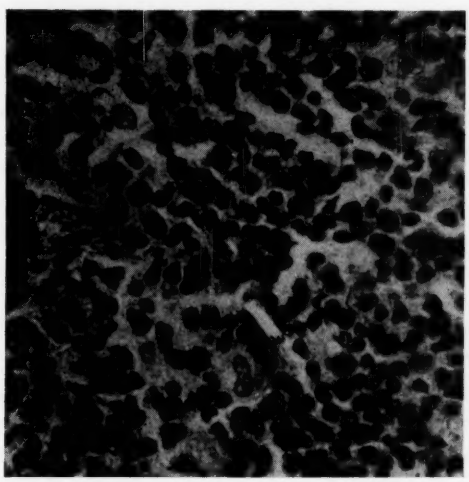

FIG. 145.—Same case. Lymphosarcoma showing tumour cells. (× 450.)

perforation. At operation a growth was found about 12 in. from the duodenojejunal junction. It was adherent in part to the descending colon and to the parietal peritoneum. Lymph-glands in the mesentery were enlarged to the size of an orange. The growth involved the whole circumference of the bowel and by weakening of the wall and ulceration had produced a saccular dilation of the lumen without evident obstruction (*Fig.* 142). It had perforated near where it was adherent to the colon. Histologically it was a lymphosarcoma and relatively

large cells with polyhedral or rounded nuclei invaded all coats of the bowel (*Figs.* 143–145). Near areas of ulceration infiltration by eosinophil polymorphonuclear leucocytes was a prominent feature. This patient died following an exceedingly difficult resection. No autopsy was permitted.

A lymphosarcoma occurred in a boy, aged 20 years (*Case* 20), and was associated with a stenosing lesion. Only an incomplete clinical record is available. It states that he had frequent attacks of severe colic and that a barium meal was delayed in the small intestine. Ullman and Abeshouse (1932), reviewing all the cases, found that dilatation was rather more frequent than stenosis.

In the absence of obstruction the primary growth may remain inconspicuous and secondary deposits may prove misleading. On general grounds the lungs might be expected to be involved more often than in the 2 cases in 18 with metastases reviewed by Ullman and Abeshouse (1932). The symptoms directed attention to the secondary deposits in the lungs in the following case :—

Case 21.—A married woman aged 57 years had enjoyed good health apart from " stomach trouble " eight years earlier. Four months before admission she developed a persistent dry cough, and prior to admission she had lost over a stone in weight. The cough had persisted, but there were no other symptoms. A radiological examination of the chest showed a large ovoid area of dullness in the right lower lobe. There was no leucocytosis and the blood-Wassermann reaction was negative. A single-stage lobectomy was performed. The tumour was reported as a small round-cell carcinoma.

Four days later the patient died, and at autopsy the lungs were œdematous and the seat of a diffuse bronchopneumonia. Four inches distal to the pylorus, and just beyond the ampulla of Vater, there was a slightly elevated plaque. It was ovoid in shape and nearly 2 in. in its greatest length, which tended to encircle the duodenum. Here there was no scar tissue and all the muscle coats of the duodenum appeared a uniform white. The lumen of the bowel was not significantly reduced and the stomach was normal. Histological examination showed that all the coats of the duodenum were densely infiltrated and almost entirely destroyed by small and relatively uniform round cells with deeply staining nuclei and very scant cytoplasm. The resemblance to lymphocytic cells was much closer than in the previous cases. The overlying mucosa was almost entirely lost. As well as the large tumour mass in the excised right lower lobe, a few minute foci of similar cells were found in the remaining lung tissue.

SECONDARY TUMOURS

Those cases in which the small intestine was involved with the rest of the peritoneal cavity in widespread and diffuse secondary deposits are not considered. A number of cases in which the small intestine was involved as the result of tumours elsewhere are of interest, as in some cases this involvement dominated the clinical or pathological picture.

In two cases the peri-ampullary part of the duodenal wall was infiltrated by tumour tissue and the presenting symptom of 3 and 5 months' duration was jaundice. Such growths (one formed a circular raised plaque extending $\frac{1}{4}$ in. all round the ampullary orifice) are often described as primary growths of the peri-ampullary duodenal mucosa. The early development of biliary obstruction and the perfectly radial manner in which the growth destroyed the duodenal mucosa and spread in the duodenal muscle wall around the central orifice suggests that the primary malignancy was more probably in relation to the ampulla of Vater. In such cases the condition is advanced and it is often idle to express definite views on the exact origin.

Two autopsy specimens showed ulceration of the first and second parts of the duodenum. They occurred in a male, aged 54, and in a female, aged 61 years. In the first there had been a " soreness " rather than pain in the abdomen for five

months. It was most severe about two hours after food and was relieved only for the first three months by more food. A hard mass later became palpable in the epigastrium. In the female subject there was only a six-weeks' history of loss of appetite and energy, with vomiting several times a day. Externally, the pancreas appeared normal in the first case and it was only after detailed study of sections that a primary adenocarcinoma of the duodenum appeared unlikely, and the condition in both was recognized as more consistent with a primary growth of the head of the pancreas.

An autopsy performed on a 47-year-old male dying with an undiagnosed abdominal tumour revealed a seminoma which had enlarged the testicle to rather more than twice its normal size. The para-aortic lymph-glands were most extensively invaded and lymph permeation by tumour cells had occurred throughout all the coats of the relatively fixed third portion of the duodenum. Lymph channels in the submucosa were blocked and dilated and the mucosa was ulcerated.

In two cases a secondary melanoma growing in the submucosa produced an intussusception and demanded urgent surgery. One case occurred 25 years after removal of an eyeball for a tumour. There is unfortunately no histology of the eye, but it may well have been the seat of the primary growth. Equally long latent periods have been recorded. In the other case a man of 43 years was awakened with severe and crampy abdominal pain. He vomited incessantly. Tenderness was maximum in the right lower quadrant of the abdomen, but a small mass was palpable just above and to the left of the umbilicus. Operation the same day revealed an intussusception 2 ft. from the duodenojejunal junction. The intussuscepted bowel presented one large and several smaller pedunculated melanomata. The patient died several months later from further metastases of a primary choroidal growth.

Two cæcal tumours, one an adenocarcinoma and the other a lymphosarcoma, showed some direct extension beyond the ileocæcal valve. No comprehensive study of gastric neoplasms has been undertaken, but involvement of the first part of the duodenum by direct extension appears to be very rare and entirely subsidiary to involvement of the stomach wall.

DIAGNOSIS

This is rarely possible before operation. Few will feel sufficiently confident to exclude the much more common stomach and colon growths if these organs appear normal on radiological examination and to diagnose a small gut tumour in the presence of persistent symptoms. Rarely the symptoms may suggest disorders of the gall-bladder or appendix. Diagnosis of the nature of the tumour even at operation may not be easy, though the annular type of malignant growth is distinctive. In all cases resection of a portion of gut is wiser than attempts at local removal.

Symptomatology.—The symptoms of benign and malignant growths do not differ greatly, and even the duration of symptoms may prove misleading. Obstruction may be acute and unheralded (*Case* 1). It is then due to intussusception. A period of partial obstruction may precede the intussusception (*Case* 2) and the onset of intussusception may be difficult to distinguish from the onset of complete obstruction from narrowing of the lumen either by a simple tumour (*Case* 10) or by a malignant growth (*Case* 14). In three simple growths (*Cases* 1, 2, and 10), including two with intussusception, and in two carcinomata (*Cases*

14, 15), symptoms suggesting complete obstruction developed. The absence of symptoms of obstruction may prove misleading as in *Cases* 19 and 21, and this is especially so in lymphosarcomata.

The intermittent crampy abdominal pain of partial obstruction was para-umbilical or sub-umbilical in distribution. It rarely seemed to have any clear relationship to food. Vomiting occurred earlier and was more frequent than in colonic new growths. Distaste for meat or other food was not a complaint. The passage of blood in any form with the stools was only rarely observed and only in benign growths (*Cases* 2, 4, 6). Its occurrence must not be held to indicate malignancy. Hæmorrhage was severe in 3 of the 6 benign tumours of the duodenum reported by Balfour and Henderson (1929). Observations of the pulse and temperature supplied no information of any diagnostic value.

A palpable mass in the abdomen was present in two of the three intussusceptions caused by simple tumours (*Cases* 2, 7), and in one caused by a melanoma. A palpable lump was associated with subacute obstruction in a lipoma of the ileocæcal valve (*Case* 4) and in a carcinoid tumour of the ileum (*Case* 13). Associated with symptoms suggesting complete obstruction an abdominal tumour was palpated in a leiomyoma (*Case* 6) and in a carcinoma (*Case* 15).

Radiography.—Routine but fairly adequate radiological examination was made in 9 cases. In two, a carcinoma (*Case* 16) and a stenosing lymphosarcoma (*Case* 20), the appearance of a 'hold up' was considered suggestive of obstruction in the small intestine. In another (*Case* 10) there was only very slight 6-hour ileal stasis six weeks before complete obstruction by a leiomyoma. In one case (*Case* 4) some persistent irregularity of the cæcum was associated with a polyp hanging from the ileocæcal valve. Twice radiology was misleading and pointed to the transverse colon as the site of the lesion. The difficulties imposed by the length and mobility of the small intestine are discussed by Raiford (1931). Negative findings are entirely valueless. A bulbous shadow on the proximal side of the tumour is rare and filling defects are only significant if demonstrated in repeated films.

Intussusception.—Intussusception occurred in 3 simple tumours (*Cases* 1, 2, 7) and in two secondary melanomata. It was confined to pedunculated tumours growing in the submucosa. Intussusception after the first or second year of life is rare. Its association with tumours of the wall of the intestine has been noted, and Eliot and Corscaden (1911) were able to record that in 300 reported cases in the entire intestinal tract 60 were associated with a benign tumour and 40 with a malignant growth.

In two intussusceptions, one produced by a lipoma (*Case* 1) and the other by an adenomyoma in an infant of 17 months (*Case* 7), the greater part of the intussusception lay distal to the tumour. Wardill (1925) has illustrated two similar intussusceptions. If the tumour does not form the apex of the intussusception it seems necessary to assume that the bowel for a short distance beyond the tumour is thrown into spasm and that this part then threads itself into the relaxed bowel distal to it. The incorporation of all parts of the bowel may not proceed uniformly, and a segment of the circumference of the bowel at the apex of the intussusceptum may be distended and stretched and create an incorrect impression as to the number of layers involved at that level.

SUMMARY

A review of 2434 autopsies and 10,705 biopsy specimens has yielded 21 primary tumours of the small intestine. There were 5 lipomata, 3 adenomata, 2 leiomyomata,

1 pedunculated subserous fibroma, 2 argentaffinomata, 4 adenocarcinomata, and 4 lymphosarcomata. The clinical and pathological findings have been reviewed and 4 examples of pancreatic heterotopia have been described and differentiated. It is also suggested that much care is required before a tumour involving the duodenum is accepted as primary, and 4 such cases are rejected.

A pre-operative diagnosis is rarely possible and benign tumours may produce symptoms resembling malignant disease elsewhere in the intestinal tract. This is especially so as regards hæmorrhage from the bowel or the presence of a palpable mass in the abdomen. Acute symptoms due to intussusception occurred in association with 2 submucous lipomata and 1 adenomyoma, and also in 2 secondary melanomata growing in the submucosa.

I wish to thank Professor J. H. Biggart for advice and encouragement; many members of the honorary visiting staff of the Royal Victoria Hospital for information about both hospital and private cases; Mr. W. W. Bassett, F.R.C.S., for *Case* 11; and Mr. D. Mehaffey, photographic technician to the Department of Pathology.

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SHORT NOTES OF RARE OR OBSCURE CASES

A CASE OF SPONTANEOUS INTRAPERITONEAL RUPTURE OF THE URINARY BLADDER

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THE following case is interesting because of its rarity. The diagnosis was revealed at post-mortem examination.

CASE REPORT

Female, unmarried, aged 27 years, gave a history that on Oct. 20, 1940, while returning home she fell on her abdomen. There was no loss of consciousness, but following the fall she had severe pain on the right side of the abdomen which made it difficult for her to get up. With the help of her friend she reached home and stayed in bed until she was admitted to hospital on the evening of Oct. 23, 1940. The pain had persisted and had prevented sleep, and she had vomited a number of times on the day of admission. The bowels had not opened since the onset of pain, but she had passed some flatus; micturition was normal. Menstrual periods were regular, the last one was two weeks ago. The patient's description was not very coherent.

CLINICAL FEATURES ON ADMISSION.—Temperature, 98·8°; pulse, 98–108; respiration, 36. Tongue dry, coated. Abdomen distended, free fluid in peritoneal cavity. Marked tenderness in right upper abdominal quadrant. Liver dullness lessened, almost abolished. Thirty-eight oz. of urine withdrawn by catheter, sp. gr. 1018, acid and loaded with albumin. Blood-pressure, 125–85. Rectal examination negative. Fundus oculi were normal on both sides.

A white-cell count showed: leucocytes, 20,300 per c.mm.; polymorphonuclears, 90 per cent; lymphocytes, 8 per cent; hyaline corpuscles, 2 per cent. A centrifugalized deposit of part of the urine withdrawn by catheter showed blood and pus cells, but no casts. This was thought to be due to a cystitis.

Among other things a diagnosis of ruptured bladder was considered but was ruled out on account of the amount of urine withdrawn at the first catheterization.

As her pulse-rate was not rising, it was decided to temporize.

On Oct. 24, next day, her condition was much the same, except that she was inclined to be drowsy. She had passed 2 oz. of blood-stained urine during the night. Pulse-rate still 108. Temperature 98·4°. Red-cell count 5,700,000 per c.mm.; white-cell count 22,000 per c.mm., polymorphonuclears 94 per cent. Blood-urea, 115 mg. per 100 mils. The abdomen was still distended and there was general tenderness and muscle resistance, but no rigidity of the abdominal wall. She passed 3 oz. of urine in small quantities.

On Oct. 25 she was very drowsy and apparently uræmic; she passed 2 oz. of urine during the night and also 1½ oz. of blood per urethram. Catheterization obtained 8 oz. of urine. There was occasional vomiting and she died during the morning about 40 hours after admission, apparently of uræmia.

POST-MORTEM EXAMINATION.—I am indebted to Dr. I. B. Morris, the pathologist, for the following post-mortem report and account of inquest proceedings:—

"Body well covered. There was no sign of external injury. The thoracic organs were quite healthy. The abdomen contained about two pints of fluid, which had the appearance of urine. There were mild inflammatory changes on the surface of the gut, and here and there were flakes of lymph.

"All abdominal organs were quite normal except for the bladder, which showed an intraperitoneal rupture on the posterior surface. The rupture ran longitudinally and was about 1 in. in length. The bladder itself was healthy and there was no evidence of disease, stricture, or trauma of the urethra. The uterus and appendages were normal.

"As there was a history of a fall the Coroner has been informed."

The story at the inquest was gone into very thoroughly owing to the post-mortem findings and was as follows:—

The deceased and her friend, a female, went together to a club about 4 miles away from their home. While there the deceased consumed a white port and half a pint of beer. On leaving the club she said she did not want to pass water and she and the friend started walking as there was no bus in sight. Her friend said the deceased was particularly cheerful and bright and was enjoying the walk. Suddenly when about a mile from home she fell down flat and then complained of abdominal pain. She was asked what made her fall and she said she did not know. She had a slight pes cavus but when asked whether her foot had given way she said emphatically that it had not, neither had she tripped. Her friend examined the pavement and could find nothing there to make her trip up. She was helped home. She had not passed water for 4½ hours. It is thought that the shock of the sudden intraperitoneal rupture of the bladder caused her to fall.

DISCUSSION

Reviewing the literature, it appears that A. T. Jones[1] states that "non-pathological rupture of the bladder is a rare condition".

A. E. Chisholm and R. L. Ferguson[2] report a case of acute intraperitoneal rupture of the bladder and at operation a similar rupture described as "a hole in the fundus of the bladder large enough to admit the point of the index finger and that the rupture had apparently taken place three days previously". This case was fatal, and the authors quote the mortality-rate given by Hamilton Bailey as "11 per cent where operation is performed within twenty-four hours, after that it rises to 55 per cent".

R. W. Barnes and A. A. Steele[3] report a case of a man aged 34 who had sudden abdominal pain on micturition and had not passed urine for four hours prior to this. "On admission to hospital at once catheterization produced 350 c.c. of blood-stained urine and the rupture was seen through a cystoscope and laparotomy revealed a ragged laceration of the bladder large enough to admit three fingers, and no other intraperitoneal injury was discovered. The laceration was sutured and bladder drained by an indwelling suprapubic drain and there was an uninterrupted recovery and the patient left the hospital in good condition on the fifteenth post-operative day."

Eric Stone[4] in 1931 published a lucid paper and stated that in 21 cases no lesion of the bladder to account for rupture was found; he places the probable cause of rupture in these cases as:—

	Cases
Manual expression of the placenta five days post partum	1
Rupture of distended bladder during labour	5
Attempted micturition during acute retention	6
Intoxication	3
Straining at stool	3
Sudden lifting of a weight	3

Stone states the mortality-rate is 45·4 per cent in intraperitoneal rupture of the bladder. He describes operative procedure to be simple and states that "given free suprapubic drainage of the bladder the repair of the rent is unnecessary".

In this case which is now reported there was no evidence of strain and no urinary infection, stricture, or abnormality of the urethra to cause bladder distension, and apparently the patient did not strain to micturate since she was walking home. It must be considered to be a spontaneous rupture of a normal bladder.

The obvious criticism of the investigation is that on Oct. 24, the day after admission, when only 2 oz. of urine were withdrawn by catheter, the return of a measured quantity of fluid introduced into the bladder should have been estimated.

This case is reported as a true non-pathological spontaneous rupture of the bladder.

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INTESTINAL STRANGULATION COMPLICATED BY RUPTURE OF A SIX MONTHS' GRAVID UTERUS

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SEVERAL features make this a most interesting, if rare, condition, and therefore it appeared to me important that a record of the circumstances should be made.

CASE REPORT

At 12 noon on Aug. 3, 1939, I was called urgently to see a pregnant Hindu woman of 32 years, who complained of violent abdominal pain low down in the right iliac fossa, vomiting frequently, and complete stoppage of fæces and flatus.

HISTORY.—Pain began on the morning of July 31 after an effort at stool. It was sharp and colicky, relieved by pressure. She vomited once. After lying down the pain grew less, until by evening it had disappeared completely. About midday on Aug. 1, after not feeling well all morning, she was suddenly seized with a violent call to stool which produced very little result; pain of a severe colicky type rapidly followed the effort. The pain came on at intervals of about ten minutes and was severe enough to make her faint at times. Vomiting commenced shortly after the onset of pain, and had occurred either with the pain, or soon after the onset of each bout of colic pain, every ten minutes up to the time I saw her.

No relief was obtained that day or night in spite of the efforts of a series of Kabirajs, homeopaths, and others. By the morning of Aug. 2 she was extremely ill and relatives decided to bring her to hospital, where she arrived just before noon on Aug. 3, having travelled all day and night by bullock cart from her village.

There was a history of six months' amenorrhœa and a sufficiently enlarged uterus to support the history. Fœtal sounds were present. Six previous pregnancies were normal. No other past history could be elicited.

ON EXAMINATION.—Temperature 99°, respiration 25, pulse 100. Very dehydrated. Tongue dry. She had not passed urine all day. Head, neck, chest, heart, and lungs all functionally and anatomically normal.

Abdomen.—Lower half distended, particularly from the right iliac fossa up across the centre. The uterine swelling could be easily made out apart from this distension. There was rebound tenderness in the region just above Poupart's ligament on the right, and tenderness to ordinary palpation in the right fossa generally.

Explosive intestinal sounds were heard in the right iliac fossa.

It was noticed that the vomiting was less than the history described and that the colic was very much less. The uterus was felt to harden synchronously with the spasms of colic, but there was no pain in the sacral region.

Per Rectum.—The rectum was empty. Three enemas were given, the first producing scybala, the last two returning clear.

Per Vaginam.—Pregnant cervix. No blood. A mass, very tender, was palpable in the right fornix, rising up into the right iliac fossa.

A diagnosis was made of small gut strangulated by a band. Operation was decided upon, to be preceded by intravenous saline and glucose at 60 drops per minute for one or two hours; duodenal decompression by a Ryle's tube introduced through the nose, and left in.

OPERATION.—By 3 p.m. her condition was considered to be fit to stand operation and she was brought to the table. As she was being arranged and made comfortable, she complained of colic and sat up with a scream, her face blanched, and she collapsed. Her pulse became uncountable and she showed all signs of an intraperitoneal catastrophe with severe shock and probably hæmorrhage. The intravenous continuous drip was turned on to 100 drops per minute. Coramine was given twice at ten-minutes' interval. A 20° Trendelenberg position was arranged on the table. After forty-five minutes the pulse recovered to 145, but the temperature was 96·0° F.

It was decided that the abdomen should be opened with all speed. When the part was uncovered the uterine swelling had disappeared and fœtal parts were palpable in the abdomen.

A midline sub-umbilical incision was made under light ether anæsthesia with novocain locally. Blood, free in the peritoneal cavity, could be seen before the peritoneum was opened. The placenta presented in the wound, and the child was found lying under the spleen. After removal of these, the blood was mopped up and the fluid carefully cleared out of the peritoneal cavity.

The uterus was completely ruptured from the base of the bladder to the pouch of Douglas over the fundus. It was firmly contracted down, the two edges being splayed out. The small intestine was found leading through a small tight fibrous-edged aperture on the posterior aspect of the right broad ligament close up to the wall of the uterus. The uterine artery lay in the lower edge of this hole. On the anterior side was a black loop of intestine swathed in omentum. The small gut led out through the same hole in the broad ligament.

The portion strangulated was about 3 ft. from the ileocæcal junction, and measured 2 ft. after excision.

The uterus was closed by interrupted deep and superficial silkworm sutures after freshening the torn edges. This closure proved difficult on account of the contracted state of the uterus and its friability.

Next a suitable point on the proximal small intestine above the strangulation was selected and clamped between two Kocher forceps. A point 6 in. from the broad ligament aperture on the distal small gut was similarly clamped. The intestine was severed between each pair of clamps. The mesentery having been suitably ligatured, the proximal (uppermost) and the distal (lowermost) ends of intestine with their Kocher forceps in position were brought out of the wound. The ends of the strangulated segments were whipped over with a running seromuscular suture without knots to bury the crushed ends when the Kocher forceps were released and slipped out from below this suture. The ends of these ligatures were tied and buried by purse-string sutures. The ends of the intestine to be anastomosed were treated similarly, except that the running suture ends were held up by forceps, instead of being tied, whilst a continuous seromuscular suture was placed to join the two limbs posteriorly and anteriorly, completing the anastomosis. When this was complete the two running sutures were withdrawn and a finger pushed into the sutured ring, by invaginating the intestinal wall, to open up the crushed parts and establish continuity of the bowel lumen. Omentum was wrapped around the suture line of the anastomosis.

The right Fallopian tube was then divided between Kocher forceps and the strangulated bowel segment lifted out of the abdomen intact. The Fallopian tube ends were ligatured and covered by peritoneum with purse strings. The abdomen was closed without drainage.

The pulse at the end of this operation was 120, temperature 99·0° F., respiration 25. The operation took ninety minutes in all.

AFTER-TREATMENT.—This consisted of continuous intravenous saline for four days, with sips of water by mouth on the third day. One injection of Progynon B Oleosum was given on the third day to dry up the milk secretion.

The patient made an uninterrupted recovery and was discharged walking 21 days after operation.

DISCUSSION

The features of interest are the clear observation made during the examination of the patient that the uterus was contracting synchronously with the onset of intestinal colic, and that on the table the patient complained of another bout of colic at which moment the uterus ruptured.

Rupture of a six months' gravid uterus must be a rare occurrence; I can find no account of such a happening in the literature available. The combination of this event with, and as a complication of, intestinal obstruction must be excessively rare.

The type of agent causing the obstruction in this case is known, but not common; Janes,[1] Hunt,[2] and Collins[3] give good accounts of the condition.

The type of resection and anastomosis performed is most simple and reliable, requires no special instruments, and is absolutely aseptic. I have used the method for the last eight years in all intestinal resections with anastomosis (small and large gut), with an operation mortality from all causes of 12 per cent taking all cases together. Mortalities are high in this country, for cases come late and are generally very bad risks from other causes.

The uterine contractions would appear to have been of the nature of part of a mass reflex initiated by the intestinal contractions. It was interesting to note how tightly contracted the uterus remained. This probably saved the patient's life by arresting all but the initial hæmorrhage.

I am indebted to Dr. W. Anderson, in charge of the Duchess of Teck Hospital, Patna, Bihar, for the opportunity to observe, operate upon, and record this case, and to the staff of that hospital for their able and willing co-operation in the treatment of the case.

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REVIEWS AND NOTICES OF BOOKS

The Early Treatment of War Wounds. By WILLIAM ANDERSON, O.B.E. (Mil.), M.B., Ch.B., F.R.C.S., Surgeon and Lecturer in Surgery, Aberdeen Royal Infirmary; Surgeon to Municipal Hospitals, Aberdeen; Surgical Director, Emergency Medical Service, Northern and North-eastern Districts. $6\frac{5}{8} \times 4\frac{1}{4}$ in. Pp. 96 + xii, with 12 illustrations. 1941. London: Oxford University Press (Humphrey Milford). 5s. net.

THIS small book is one of the Oxford War Primers, under the general editorship of Lord Horder. In one sense this series represents a revision of that published during the last war, and the books are written by men who had experience of that catastrophe. Its opening chapters deal very largely with matters of organization, of advanced dressing stations and casualty clearing stations. It is not quite clear to what extent the distinction of these units will be applicable to affairs in the present war.

There is then a brief description of the principles of treatment of wounds, wounds of the brain, penetrating wounds of the abdomen, and penetrating wounds of the thorax. The last chapters deal with wounds of the joints, vertebral column, nerves, and arteries.

The possibilities of combating wound infection by drugs of the sulphonamide group are hinted at, rather briefly, as are the modern methods of blood transfusion. The small volume contains a great deal of useful information, packed into a small space.

Medical Organization and Surgical Practice in Air Raids. By P. H. MITCHINER, C.B.E., F.R.C.S., Hon. Surgeon to H.M. The King; Surgeon and Lecturer in Surgery, St. Thomas's Hospital; Brigadier, Army Medical Service, D.D.M.S. Command; and E. M. COWELL, C.B., C.B.E., D.S.O., T.D., D.L., M.D., B.S., F.R.C.S., Surgeon, Croydon General Hospital; Brigadier, Army Medical Service, D.D.M.S. Corps. With a Foreword by Sir CUTHBERT WALLACE, Bt. Second edition. $8 \times 5\frac{1}{4}$ in. Pp. 296 + x, with 58 illustrations. 1941. London: J. & A. Churchill Ltd. 12s. 6d. net.

WE had the pleasure of writing favourably of this book on its first appearance in 1939. At that time one of the authors had been to Spain and had learned there some of the horrors of modern warfare. Since that time there has occurred the present war, with the heavy air raids in our cities and the casualties amongst the civil population. The first two chapters dealing with the organization of civil medical services in air raids and the methods of enemy air attack have been re-written in the light of recent and present-day experiences. Some additional paragraphs have been added on such matters as the use of sulphonamides and blood-plasma. A warm tribute is paid to the magnificent work done by the organization of the Emergency Medical Service. In the treatment of fractures the closed plaster technique as used by Trueta is advocated, but the use of the Thomas splint is also advised. In the chapter on abdominal surgery the illustrations are particularly good.

It concludes with a number of practical details, such as nursing organization, arrangements of the operating theatre, first aid and medical transport, chemical warfare, and mobile X-ray units.

The book will long maintain the position of authority it has achieved in teaching the essentials of war surgery.

Surgery of Modern Warfare. Compiled by Sixty-five Contributors. Edited by HAMILTON BAILEY, F.R.C.S. (Eng.), Surgeon, Royal Northern Hospital, London; etc. To be issued in five separate parts. $9\frac{3}{4} \times 6\frac{7}{8}$ in. Part IV: Section VIII contd.; Section IX, Wounds of the Face and Neck, including those of the Special Senses. Pp. 481-640. *Figs.* 503-683. 1941. Edinburgh: E. & S. Livingstone. Each part, 12s. 6d. net.

PORTIONS of Part IV were destroyed by enemy action and had to be re-written and re-illustrated. The Editor's hope that these sections cannot be detected by their hasty or slovenly workmanship is amply justified, unless *Fig.* 517, which is wrongly labelled, supplies a faint clue.

The whole of this part of the work shows evidence of the most careful and painstaking reasoning on the part of the contributors. The sections which are devoted to wounds of bones and joints and to amputations from the point of view of patient, surgeon, and artificial limbmaker, crystallize, so to speak, the general views expressed in the earlier parts of the work.

These articles should be carefully studied and absorbed by all engaged in the surgery of warfare. The indications for methods of amputation in various positions are fully discussed and beautifully illustrated. They will remain authoritative for a very long time to come.

Controversial subjects such as the treatment of the nerves in amputation, the obliteration of bone cavities, and alternative methods for splinting if plaster-of-Paris is not available are fully dealt with. It is fully realized that a certain degree of bureaucratic control is necessary in the surgery of warfare, yet it is much better that this should be of a minimal degree. The surgeon should be left to use his own judgement and practise methods in which he is experienced rather than be bound by standardization. This may be necessary to some extent in order to establish the science, but it will in no way advance the art, of surgery.

The use of plaster-of-Paris as an immediate application to the stump after amputation is well worthy of more extensive use, and will add much to the comfort of the patient and ensure a good end-result to the operative procedure.

A word of warning is rightly sounded as to the unskilful application of plaster-of-Paris. Successful technique needs long practice, and the guttering of a plaster splint should be almost a routine if the patient is not to be kept under continuous skilled observation.

The methods of drainage, when necessary, after amputation may also be of the utmost importance and are discussed fully.

The more specialized sections on wounds of the face and jaw, with the necessary plastic repair later, gives just the information required by the inexperienced. The same remarks apply to the article on orbital wounds and ophthalmic surgery, which has assumed such vital importance as the result of the modern methods of warfare.

Special Surgery in War Time. A *Practitioner* Booklet. Edited by Sir HUMPHREY ROLLESTON, Bt., G.C.V.O., K.C.B., M.D., D.Sc., F.R.C.P., and ALAN MONCRIEFF, M.D., F.R.C.P. $8\frac{1}{2} \times 5\frac{1}{2}$ in. Pp. 74 + viii. 1940. London: Eyre & Spottiswoode Ltd. 6s. net.

THIS little book seeks to initiate the general practitioner into the mysteries of special surgery from which those responsible for the medical services of the country are at present trying to debar him by insisting on the segregation of cases into special centres.

If its object is to prepare the practitioner for circumstances where specialist service is not available the book is deficient in practical detail. If, on the other hand, special surgical treatment is outside the scope of the general practitioner, the book has little use except as light reading for such as find their relaxation in 'shop'.

Mr. Zachary Cope alone seems to deal with his subject from the general practitioner's point of view, for he devotes most of his space to the question of early diagnosis and the difficulties which this may present, and it is diagnosis which should be the general practitioner's chief function. The other authors have treated their subjects rather from the specialist's point of view, presupposing in their readers a familiarity with technical details which few possess. For example, what help to the general practitioner inexperienced in these matters is the statement that "extension should be applied by the Watson-Jones or some other method"? A few line drawings illustrating some of the technical details such as this, Munro tidal drainage, a shock cage, measurement of spinal pressure, etc., would have greatly increased the value of the book.

Essentials of General Anæsthesia. With Special Reference to Dentistry. By R. R. MACINTOSH, M.A., M.D., F.R.C.S., D.A., Nuffield Professor of Anæsthetics, University of Oxford; Anæsthetist to the Radcliffe Infirmary, Oxford; and FREDA B. PRATT, M.D., D.A., First Assistant, Nuffield Department of Anæsthetics, University of Oxford; Anæsthetist to the Oxford Eye Hospital. $8\frac{3}{4} \times 5\frac{1}{2}$ in. Pp. 334 + xi, with 226 illustrations, several in colour. 1940. Oxford: Blackwell Scientific Publications Ltd. 25s. net.

THIS book is the first major publication of the Nuffield Foundation of Anæsthesia at Oxford, and it is also the first text-book to be devoted solely to dental anæsthesia. As such, it is

likely to remain the standard work on the subject for many years to come. The theory and practice of this branch of anæsthesia is treated throughout with encylopædic detail, aided by really superb illustrations, many in colour. The majority of the references are from American and Continental sources, and one feels, perhaps, that current anæsthetic opinion in this country has been rather neglected.

It is interesting to note that the authors have abandoned the theory that nitrous oxide acts solely as an oxygen replacer, considering it to act in the nature of an inhibitor of one of the enzymes involved in the process of cell oxidation. The chapter on cyanosis, with its original illustrations, merits special mention.

In the chapter on the choice of anæsthetic some trenchant opinions are expressed as to the inadvisability of consulting a physician on the anæsthetic risk in any particular case. The iconoclastic view that it is a second anæsthetist who should be called in rather than a physician, will be welcomed by the anæsthetic profession, and it is to be hoped that surgeons will also adopt this view. Too often one sees the statement 'fit for gas only' on the patient's chart, the limitations and in some cases actual danger of nitrous oxide being unappreciated by the physician.

The use of some form of premedication as an adjuvant to dental anæsthesia and analgesia is described in detail. The value of team work between anæsthetist and dental surgeon is stressed, the description of the most suitable position of the head for extraction of various teeth being particularly good. A chapter on the management of the operation for removal of an impacted wisdom tooth could have been added with advantage. The intensely practical nature of the book should be of immense value to students and resident anæsthetists, and the appearance of a companion volume on anæsthesia in general surgery will be eagerly awaited.

Treatment in General Practice—Surgery (continued). Articles republished from the *British Medical Journal*. Vol. IV. $8\frac{1}{2} \times 5\frac{1}{2}$ in. Pp. 562 + x, with 143 illustrations. 1940. London: H. K. Lewis & Co. Ltd. 16s. net.

THIS book consists of a number of articles, contributed since 1938 to the pages of the *British Medical Journal*. It is the fourth of a series, the former volumes dealing with medical disorders and anæsthesia. All the articles are contributed by well-known authorities, and therefore it is natural that every article should be of great practical value.

The most difficult problem in constructing this series of articles must have related to the choice of subjects. Presumably the idea has been to select those subjects about which the man in general practice is likely to have most difficulties. It is certainly not confined to minor surgery because it includes most fractures and such subjects as prostatectomy, but it is difficult to understand why fractures of the two extremities of the femur should be described whilst those of the shaft of the femur are omitted. In fact, the compilation as a whole consists in a series of articles of great practical value by well-known surgeons, but owing to its many omissions it cannot be regarded as a complete book of reference.

Abdominal Operations. By RODNEY MAINGOT, F.R.C.S., Senior Surgeon to the Southend General Hospital, and to the Royal Waterloo Hospital, London; etc. $9\frac{3}{8} \times 6\frac{1}{2}$. In two volumes. Pp. 1385 + xvi, with 298 illustrations. 1941. New York and London: D. Appleton-Century Co. £5 net.

THIS is a work of merit, well written, and beautifully produced. Older surgeons may perhaps regret the challenging title, but they will certainly welcome the full account and judicious discussion of the diseases of the gastro-intestinal tract and peritoneum which is here set forth. Genito-urinary and gynæcological surgery are not included.

The work is divided into eleven parts. The first part, which deals with the general technique of opening and closing the abdomen, includes a long account of the disruption of wounds, but omits any discussion of the part played by vitamin C in the healing of wounds.

Part II (over 450 pages) is concerned with the surgery of the stomach and duodenum and constitutes a well-documented and full treatise on the subject. Emphasis is laid on the relatively common occurrence of acute dilatation of the stomach, but no reference is made to the fact that a rising pulse may be the first and for some time the only indication of the condition. We do not understand why it is stated that after gastrectomy the patient may

be allowed to drink freely, while after the suture of gastric injuries no fluids are to be permitted for two or three days. In gastric diseases, and throughout the book, the value of the indwelling duodenal tube is made clear. The accounts of the various operations on the stomach and duodenum are well written, and, while the general leaning of the author towards partial gastrectomy is evident, the indications for the more conservative operations are laid down. The technique given for gastro-jejunostomy is relatively complicated compared with the simple Moynihan method, and no reason is given for the elaboration. There is an excellent account of the treatment of perforated peptic ulcer and the value of a plain radiograph in diagnosis of the condition is pointed out.

Part III describes the surgery of the spleen clearly and concisely; we think the value of diathermy in dealing with adhesions to the diaphragm might with advantage be mentioned.

In Part IV diseases of the pancreas are considered, and the technique for partial resection of the gland is described. We think it is hardly justifiable to say that radiotherapy is of questionable value in the treatment of pancreatic fistulæ.

Part V devotes 150 pages to the surgery of the gall-bladder and biliary ducts, and is worth reading carefully. It is recommended that routine incision and exploration of the common duct should be done when the gall-bladder is removed.

The less than fifty pages given to hepatic surgery is one of the least satisfying parts of the book and some parts of this will need to be amplified in any future edition.

About fifty pages are given to diseases of the vermiform appendix. The clinical account of appendicitis is adequate, but in the treatment of abscesses we miss a reference to the value of the sucker in preventing soiling of the peritoneum.

In Part VIII (peritoneum) the account of peritonitis is good, but no special description of biliary peritonitis is inserted. In the valuable account of the post-operative treatment of peritonitis it is recommended that blood transfusion be given as a routine in all severe cases.

In the account of subphrenic abscess we find no reference to the rapid onset of anæmia caused by such an abscess forming after the perforation of a peptic ulcer. Diagnostic aspiration is condemned, and it is recommended to open the abscess by the anterior or posterior extraperitoneal routes.

Part IX describes the operations for external hernia, but in no part of the work do we get a full description of the diagnosis or operative treatment of diaphragmatic hernia.

About three hundred pages suffice to describe diseases of the intestines—including cancer of the rectum. There is an excellent account of cancer of the colon and its operative treatment. The author gives support to Paul's exterior operation for this disease. Volvulus is not so satisfactorily dealt with; it is stated "if there is marked distension the involved coil of bowel should be eviscerated, deflated by puncture and aspiration, etc.". This advice is unnecessary, for if the coil can be brought outside it can always be untwisted and then emptied by a tube passed up the rectum. We agree that a recurrent volvulus is best excised by Paul's method. In considering the diagnosis of intussusception it is recommended that in doubtful cases the abdomen should be palpated under an anæsthetic—a procedure which can usually be avoided by looking at the gut under the X rays after giving a barium enema.

The final section on pulmonary complications is by Dr. Sleigh Johnson, and that it is up to date is shown by the fact that there is an account of the technique for administration of heparin for the prevention of thrombosis.

The book is lavishly illustrated and beautifully printed, and there are many useful references and historical notes. The index is inadequate and only to be found at the end of the second volume. There is no separate index of names. By writing this work Mr. Maingot will put many surgeons in his debt, for it is likely that these two volumes will be indispensable occupants of the bookshelves of those who practise abdominal surgery.

A Complete Outline of Fractures, including Fractures of the Skull. By J. GRANT BONNIN, M.B., B.S. (Melbourne), F.R.C.S. (England), M.R.C.O.G., First Assistant to the Injury Clinic, West London Hospital; Orthopædic Registrar, St. John's Hospital, Lewisham; Acting Registrar, Royal National Orthopædic Hospital. 9⅛ × 6 in. Pp. 507 + xii, with 570 illustrations. 1941. London: William Heinemann (Medical Books) Ltd. 25s. net.

THIS is a good account of modern methods of treating fractures written by one full of enthusiasm for his subject and eager to impart his knowledge to others, and especially to students.

As he tells us in the Preface, his aim has been to write an ideal student's text-book. Both in the section on general principles (121 pages) and in that of fractures of special bones, the author follows the lines usually laid down in this country and abroad. It is interesting to one who has watched and taken part in surgical practice for many years to note how the burning questions which absorbed our attention in the last generation have now been almost forgotten—such as the relative value of the methods of open and closed treatment and of the importance of massage; whilst other subjects now demand discussion—e.g., the methods of plaster technique, the importance of providing for the early use of active exercise by the injured limb, and the importance of organizing treatment, by segregation, specialization, and continuity.

The wish to provide for the needs of a student at examinations has led to the inclusion of things which a practical guide to the subject might well have omitted; such are the Carrell-Dakin method of wound treatment and many of the six different methods of dealing with a fractured clavicle, beginning with that of Sayre's strapping.

The illustrations are numerous, clear, and excellently chosen, and it is remarkable what a large amount of information has been compressed into this small and handy book.

A Text-book of Surgical Pathology. By C. F. W. ILLINGWORTH, M.D., Ch.M., F.R.C.S. (Edin.), Regius Professor of Surgery, University of Glasgow; and B. M. DICK, M.B., F.R.C.S. (Edin.), Lecturer in Clinical Surgery, University of Edinburgh; Assistant Surgeon, Edinburgh Western Hospital. Fourth edition. $9\frac{3}{4} \times 6\frac{1}{8}$ in. Pp. 728 + viii, with 300 illustrations. 1941. London: J. & A. Churchill Ltd. 38s. net.

IN this volume the path of pathology for the general surgeon is carefully charted. It is a companion on the bookshelf for text-books dealing with the science and art of clinical surgery. With only a modest increase in size, the present edition deals with all that matters in the realm of modern research. There are adequate references to such important matters as the lack of vitamin K in obstructive jaundice. The role of the parathyroid glands in diseases associated with calcium metabolic disorders is well described. The paragraphs on tetany will be helpful to the busy practitioner.

There are short but concise accounts of conditions which are absorbing attention at the present time. Wound infections, gas gangrene, traumatic shock, burns, and tetanus receive appropriate attention. A good description of diseases of the peripheral nerves is included, but reference to the sympathetic system is absent. We can repeat with confidence what was said when reviewing the third edition, "This book overflows with practical information, linking clinical with pathological facts, and bedside problems are clarified by reference to its contents".

The authors have taken care to avoid 'padding' for the sake of the overburdened student of surgery, who is almost submerged by the flood of literature in relation to the war.

We recommend those who aim at an accurate pre-operative diagnosis, to consult this text-book whenever in doubt.

Illustrations of Regional Anatomy. By E. B. JAMIESON, M.D., Senior Demonstrator and Lecturer, Anatomy Department, University, Edinburgh. Third edition. $8 \times 6\frac{1}{8}$ in. Section I, Central Nervous System (49 plates), 7s. 6d. net; Section II, Head and Neck, (64 plates), 15s. net; Section III, Abdomen (41 plates), 6s. net; Section IV, Pelvis (34 plates), 4s. net; Section V, Thorax (31 plates), 4s. net. 1941. Edinburgh; E. & S. Livingstone.

THIS consists of an atlas of anatomy, all the drawings of which are of great artistic merit and of diagrammatic simplicity. Each section is provided with a loose-leaf binding case, so that the plates can be removed and replaced. The very rapid disposal of the last edition shows how much this atlas has been appreciated. The chief change in the present edition has been the increase of colour, no less than 300 new colour blocks having been prepared. Over 50 of the figures now display four colours.

The author and publishers are to be congratulated on having produced so very handy a work, containing such a vast amount of information. It will continue to be used for purposes of reference both by students and practitioners.

Histopathology of the Peripheral and Central Nervous Systems. By GEORGE B. HASSIN, M.D., Professor of Neurology, University of Illinois, College of Medicine; Attending Neurologist, Cook County Hospital, Chicago. Second edition. 9¼ × 6⅛ in. Pp. 554 + xxv, with 302 illustrations. 1940. London and New York: Paul B. Hoeber, Inc. (Medical Book Department of Harper & Bros.). $7.50.

THIS second edition of Dr. Hassin's work on histopathology has been enlarged to include an introductory chapter on the normal and pathological histology of the nervous system which provides the student with a better foundation on which to build his knowledge of the various and intricate departures from the normal which are met with in degeneration and disease of the nervous tissue, and there is also new matter dealing with diseases of the cerebellum and with encephalitis. Many of the illustrations have been altered and improved.

It is only natural that by far the greater part of the book should deal with degenerative, abiotrophic, and vascular lesions of the brain and spinal cord, and those conditions which are of more immediate interest to the surgeon—injuries, infections, and neoplasms—though adequately described from the point of view of the student or the neurologist, are necessarily allotted such a minor place that the surgeon cannot expect to get much help or guidance from the accounts which are given here. This must not be regarded as adverse criticism, for the 'surgical' diseases cannot be regarded as of major importance in the whole realm of neuropathology.

It is probably true, however, to say that although the author's object has been to describe pathological changes in relation to clinical manifestations, the book deals almost entirely with histology, even the space devoted to individual lesions bearing little or no relation to their clinical incidence or importance. It is beautifully illustrated and serves a most useful purpose as a guide to the morbid anatomist who desires to study the technique of preparing specimens of nerve tissue, and the histological manifestations of nervous disease.

BOOK NOTICES

[*The Editorial Committee acknowledge with thanks the receipt of the following volumes. A selection will be made from these for review, precedence being given to new books and to those having the greatest interest for our readers.*]

The Science and Practice of Surgery. By W. H. C. ROMANIS, M.A., M.B., M.Ch. (Cantab.), F.R.C.S. (Eng.), F.R.S. (Edin.), Surgeon and Lecturer on Surgery, St. Thomas's Hospital; etc.; and PHILIP H. MITCHINER, C.B.E., T.D., M.D., M.S. (Lond.), F.R.C.S. (Eng.), Hon. Surgeon to H.M. the King; Hunterian Professor, Royal College of Surgeons of England; Surgeon and Lecturer in Surgery, St. Thomas's Hospital. Seventh edition. In two volumes. 9¾ × 6 in. Vol. I: General Surgery, 895 + x, with 413 illustrations. Vol. II, Regional Surgery, pp. 1057 + x, with 346 illustrations. 1941. London: J. & A. Churchill Ltd. 15s. net each volume.

Surgery of the Heart. By E. S. J. KING, M.D., M.S., D.Sc. (Melb.), F.R.C.S. (Eng.), F.R.A.C.S., Major A.A.M.C., Honorary Surgeon to Out-patients, Royal Melbourne Hospital; etc. 9½ × 5⅝ in. Pp. 728 + xii, with 268 illustrations. 1941. London: Edward Arnold & Co. 50s. net.

Emergency Amputations. Memorandum by H. A. T. FAIRBANK, D.S.O., O.B.E., M.S., F.R.C.S.; Surgeon Rear-Admiral G. GORDON-TAYLOR, O.B.E., M.S., F.R.C.S.; Colonel C. MAX PAGE, D.S.O., M.S., F.R.C.S.; P. JENNER VERRALL, M.B., F.R.C.S.; and R. WATSON-JONES, M.Ch., F.R.C.S. (Members of the Sub-Committee on Amputations, Medical Research Council War Wounds Committee). 9¾ × 6⅛ in. Pp. 8, with 2 illustrations. 1941. London: H.M. Stationery Office. 2d. net.

Technique of Gastric Operations. By RODNEY MAINGOT, F.R.C.S. (Eng.), Senior Surgeon to the Southend General Hospital and to the Royal Waterloo Hospital, London; etc. 8¾ × 5½ in. Pp. 240 + xii, with 55 illustrations. 1941. London: Oxford University Press. 15s. net.

A Cirurgia Conservadore nas Nefropatias (Cirúrgicas e Médicas). By Dr. RODOLPHO DE FREITAS, Professor de Clinica Urológica da Escola Paulista de Medicina; etc. 10½ × 7 in. Pp. 274 + viii, with 271 illustrations. 1940. São Paulo.